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The Development of a Beam-Walking Test and Its Use in Measuring Development of Balance In Children

By Harold G. Seashore*
The Psychological Corporation
New York City
(Submitted for publication, April, 1947)

INTRODUCTION

THE writer and his students were interesting in developing more adequate measuring devices and procedures for appraising the development and present status of motor abilities in children and adults. The students who worked on the project had in common an interest in contributing to the scientific foundations for curricular planning in physical education. The concept of balance kept thrusting itself into the picture and a survey of the literature indicated that little fundamental work had been done in the matter of measuring balance, conceived as a gross motor functioning. Many studies, well known to physical educators and psychologists, have been done in the field of fine motor coordinations, beginning with the classical work of Whipple and currently exemplified in the commercially available tests of motor skills used in vocational selection.

Whitney, [1] Dain, [2] and Hanson [3] took as their general problem the measurement of balance as exemplified in the universal activity of walking.

Whitney and the author sought to develop a test of balance which would be practical to administer, would yield a good range of scores even among adults, and would be reliable. The test also was expected to be useful over a wide age range, such as in the whole school system. The literature revealed several attempts at using the beam-walking type of test, but none had been very successful. [4] Dain's

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*During the years 1936-1941, the writer supervised a series of motor ability projects while professor of psychology at Springfield College. Several masters' theses were sponsored. A comprehensive report of these studies was published in 1942: Seashore, Harold. Some relationships of fine and gross motor abilities. *Res. Quart.*, 1942: 13, 259-274. The Beam-Walking Test was described briefly. In the present paper, its development and application are reported. The cooperation of the graduate students, Dr. Leonard Larson, and the National Research Council, which contributed a grant, is acknowledged.

1 Everett Whitney. A beam-walking test of dynamic balance. M. Ed. thesis, Springfield College Library, 1937, 53 pp. and appendices.

2Charles Dain. The measurement of dynamic balance in boys between ages 13 to 18 with a beam-walking test. M. Ed. thesis, Springfield College Library, 1938, 62 pp. and appendices.

3William Hanson. Performance of younger boys on a beam-walking test of balance. M. Ed. thesis, Springfield College Library, 1941, 40 pp. and appendices.

4A survey of the field is not included here; the three theses listed above contain rather complete references through 1940.

and Hanson's studies applied Whitney's test, with modifications, to a sample of boys from 5 to 18 years of age.

This paper is concerned with reporting the development of the beam-walking test. The research is obviously incomplete, but since the author is no longer in a position to carry on the project, it seems desirable to share the data now for the benef t of other investigators in the fields of physical education and psychology.

DEFINITIONS

One is impressed with the fact that the terms "balance," "steadiness," and "equilibrium" are used freely without formal definition. Are these terms synonyms, are they overlapping, or are they names of distinct motor functions?

Two broad types of balance can be differentiated: *static balance* and *dynamic balance*. These can be defined in terms of their physical relations, their neuromuscular relations, and their psycho-motor relations.

Physically, *static balance* refers to the case of a body acted upon by forces whose resultant is zero. Neuromuscularly, static balance refers to the maintenance of a specified posture in which the antagonistic muscles are so employed that there is a minimum of general body sway or finer muscular movements. Psychologically, static balance refers to the postural orientation of the body when the organism is motivated to remain motionless. Synonyms are static equilibrium and steadiness. The term may apply to the whole body or to a segment. Examples are the stance of a rifleman, posing for a photographer, peering into a microscope, keeping one's foot evenly on the accelerator of a car at uniform speed. Typical experiments with this type of balance employ Miles's ataximeter or some form of steadiness apparatus similar to Whipple's.

Physically, *dynamic balance* refers to the case of a body whose weight is so distributed that the resultant of the forces is varying from moment to moment. Neuromuscularly, dynamic balance refers to the ma'ntenance of an organized postural orientation under conditions in which the activity pattern of the muscles is continually changing so as to disturb the gross postural orientation and require further muscular activity to reestablish the orientation. Psychologically, dynamic balance refers to the postural orientation of the body when the organism is performing a specified motor activity which involves relatively large motions of all or parts of the body which act to disturb the gross orientation of the organism. Examples are dancing, walking, driving a golf club, playing a violin, firing a gun, and most motor acts in industry and athletics. The term coordination is often used to denote these larger integrations of action patterns to produce a specified kind of behavior.

In common usage, steadiness is the term which refers to static balance, that is, overtly motionless activity. The common term "bal-

ance" is usually the name given when complex motor skills are involved. However, the term balance ought to be applied generically to both situations with the qualifying terms *static* and *dynamic* to differentiate them. As a factor in motor skills, balance is intricately bound up with such factors as strength, reaction time, and sensory discrimination. Studies by Larson, [5] R. H. Seashore, [6] and the writer [7] bear on these relationships.

THE SPRINGFIELD BEAM-WALKING TEST

Several preliminary studies with the use of walking beams resulted in a progressive evolution of apparatus and procedure. Whitney, for instance, found that with adults beams wider than two inches resulted in too many perfect scores. With children as young as five, a 4-inch beam was needed. Several variations of procedure were tried; the final one chosen required the subject to walk in heel-to-toe fashion and with hands on hips. Since the test had to be practicable for schoolroom use, it was decided that street shoes should be used; sneakers and rubber-soled shoes had to be ruled out. The following description of the test is that of the apparatus used by Whitney, Dain, and Hanson, and the procedure is that of the latter two in their study with children.

The apparatus of the Springfield Beam-Walking Test consists of nine oak beams of equal length and equal height from the floor but with varying widths of walking surfaces. The variable widths are 4, 3½, 3, 2½, 2, 1½, 1, ½, and ¼ inches. Short cross braces keep the beams steady. The upper surfaces are 4½ inches off the floor and there is no evidence that this height leads to fear or will result in any accidents if the subject falls off suddenly. The beams are 10 feet long.

The task of the subject is to walk ten steps on each of these progressively narrow beams in heel-to-toe fashion with hands on hips. Rather than have the subject begin at the end of the beam and count off ten steps, the subject is placed at a starting point on the beams appropriate to his shoe-length, so that he will walk *just ten steps* from this point to the end of the beam. A simple foot-measuring board classifies all subjects into six groups, beginning with those having shoes between 7 and 8 inches in length to those having shoes 12 to 13 inches in length. Adults with the longest shoe-lengths, thus, walk the whole length. On the sides of the beams six starting points are painted in different colors, telling where a person who has a given shoe-length will begin.

Theoretically, a trial of the test consists of having the person walk

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5L. Larson. A factor analysis of motor ability variables and tests, with tests for college men. *Res. Quart.*, 1941: 12, 499-517.

6R. H. Seashore. Experimental and theoretical analysis of fine motor skills. *Amer. J. Psychol.*, 1940: 53, 86-98; and R. H. Seashore, C. E. Buxton, and I. McCollum. Multiple factorial analysis of fine motor skills. *Amer. J. Psychol.*, 1940: 53, 251-259.

7Harold Seashore., *op cit.*

first the widest beam and then each of the other eight progressively. However, after preliminary investigation it was found that a simpler technique is to have the person begin on a beam which he surely can walk but which still will challenge him. The attempt was made to arrive at a standard set of starting beams for persons of different ages with the principle that the starting beam ought to be two widths wider than the one where a person of his age might be expected to have considerable difficulty. The following practice has emerged: adults, that is, men over 18, always begin each trial on the 2-inch beam; boys from 13 to 18 begin on the 2½-inch beam and if they do well on Trial I, they begin on the 2-inch beam in the remaining trials; 9 to 12-year-old boys begin on the 3-inch beam, and if they do very well on Trial I, they start their subsequent five trials on the next narrower beam; for children under 9, the 4-inch beam is the regular starting beam in all trials. Much as in the Binet type of test, credit is given automatically for the beams of wider width which are omitted.

Details of procedure.—Alone in a quiet room with the experimenter, the subject is told and shown how to walk in heel-to-toe fashion with hands on hips. He is measured for foot-length and told where to begin on each beam. He may try a few steps on a wide beam if he likes, and most subjects do practice. (In further refinements of this test, a standard practice trial should be used. Thus, if four trials are to be scored, one could give five trials and ignore the first; it would be well not to let the subject know the first one is not counted.) The special rule regarding falling off or removing hands from hips is explained: the subject is told that when he falls off or drops his hands from his hips he is to step right back on at that place and continue as far as he can. Stepping crosswise on a beam is also considered falling off. The reason for this "second fall-off" procedure is explained in the section dealing with reliability.

Scoring.—The beams are marked in *quarter-lengths.* Since different people start at six different places, depending upon shoe-lengths, there are six such codes and colored markings of quarter-lengths. The score of the person in a trial, then, is the score value of the segment on the beam in which his "second fall-off" occurs. A perfect score on a trial is 36 points. For the genetic study reported herein, the test score is the average of the scores obtained on six trials. Four trials yield quite reliable scores with adults. If the test is ever standardized with norms, a more precise decision about practice trials and number of scored trials should be made.

The apparatus and procedure just described are those actually used. No doubt other variations would be just as useful and the author has had in mind several further refinements and alternatives. One, for instance, was to require each subject to finish the whole series of beams no matter how many errors he made; he would step

on again at each failure, and the number of fall-offs would be the error score for the subject. This plan was satisfactory with adults and actually was used in one study,[8] but it was not satisfactory with children who frequently would just quit when failures on a given board became numerous.

To date only boys have been tested. No simple way of getting reasonable uniformity in girls' footwear seemed possible, but doubtless some plan could be worked out.

The whole test requires from 10 to 15 minutes. Rest between trials is offered, but most of the older boys prefer to go right on after having walked back to the beginning beam. The task does not seem very fatiguing. Before being accepted as a standardized test of motor ability, it is likely that the timing between trials should be fixed.

RELIABILITY

Many factors can affect the reliability of testing. The most common technique for improved reliability is to increase the number of samples of behavior from each person tested, that is, to lengthen the test. But careful analysis will reveal other ways of improving reliability. Earlier research with the beam-walking type of test had suggested its unreliability. Whitney's first task was to see whether by variations of method he could find a procedure which would produce reasonably reliable measurements.

In his first exploration of the test, he had 100 adult men walk beams varying in width, 1½, 1, ½, and ¼ inches. Each of the three trials was treated as a test. The average intercorrelation among the three trials was .40. If this average is used in the formula to predict the reliability of the whole test consisting of three trials, the value becomes .66, which is much too low for practical usefulness of the test. Even a cursory glance at the individual records indicated a potential source of unreliability of measurement. Quite a few persons who proved that they really could walk very narrow beams by actually doing so on at least one trial were found to have very poor scores in another trial. For example, a person walked nearly to the end of the ½-inch beam on the first two trials, a very good performance. However, on his next trial he fell off on his second step on the first beam. Such a fall-off is obviously not due to "ability" but to some momentary lapse of attention. Control of attention may be fundamental in some situations and in the long run it is important that this variable be included in an overall measuring program. But, in this instance, the interest was in fundamental motor coordination rather than in the discipline of the person under stress and therefore it was desired to rule out the effect of these freakish errors. A simple expedient was suggested. The subjects

[8]Harold Seashore., *op. cit.* See reference to the Atkinson study in this general summary.

could be told that when they fall off or drop their hands from their hips, or step crosswise on a beam, they should step back on again and proceed, and that the "second fall-off" would be the end of the trial.

Whitney called in 100 new subjects who were tested with this procedure. For their three trials, the average intercorrelation was .53 (Table I). Using the value of .53 and applying the Spearman-Brown formula, the coefficient of reliability for a full test of three trials becomes .77.

TABLE I

INTER-CORRELATIONS OF TRIALS WHEN THE SECOND FALL-OFF TECHNIQUE WAS USED

Trials	*r*
1 and 2	.60
2 and 3	.53
2 and 3	.46

Since Whitney has also changed his scoring procedure a little to include weightings on the more narrow beams, this was not clear-cut evidence that the improved reliability was due only to the "second fall-off" procedure. To further check Whitney's conclusion regarding the use of the second fall-off technique of scoring, Dain and Hanson actually marked for each of their subjects the place where the first failure on each trial occurred. All of their data hereafter reported are based upon the second fall-off, but for this special reliability checkup, both first and second failures on each trial are involved. Odd-even reliability coefficients were computed for the six trials, once with the *first* failures as the scores and then with the *second* failures as the scores. The data are in Table II. Only some of the age groups were worked up in this manner. N was 30 at each age.

TABLE II

DATA TO SHOW IMPROVEMENT IN RELIABILITY OF THE TEST WHEN THE SECOND FALL-OF IS USED AS THE FAILURE POINT ON THE TEST

Age	*Based on First Fall-off*		*Based on Second Fall-off*	
	r^*	r^{**}	r^*	r^{**}
5	.66	.80	.78	.88
7	.49	.66	.80	.89
9	.67	.80	.74	.85
11	.49	.66	.80	.89
13	.62	.77	.77	.87

* Uncorrected, three odd vs. three even trials.
** Corrected for a test consisting of six trials.

It is felt that this study, insofar as reliability is concerned, has demonstrated the usefulness of the test. It sheds light on why earlier users of beam-walking tests had given them up or reported their essential unreliability. The writer feels that the attempts to delete the "mental hazards" from the score are legitimate provided that one is

aware that this is being done. Whenever one deliberately permits attentional factors and other inconstant variables to enter into a complex motor act, one should expect less reliability. Perhaps when measuring for certain purposes, one should use the mean deviation scores of each individual as the measure, thus capitalizing on the inconstancy itself as a variable.

Whitney called back his 100 men and asked them to complete six more trials, making nine in all. Table III summarizes the reliability data secured therefrom. Note that these values are only slightly less than the value of .77 which he predicted from his first three trials as shown in Table I, and also somewhat less than those for children as shown in Table II.

TABLE III

RELIABILITY OF THE BEAM-WALKING TEST WITH THE SECOND FALL-OFF PROCEDURE, FOR 100 ADULT MEN (WHITNEY)

Trials	r*	r**
Ave. trials 1, 2, and 3 vs. Ave. trials 4, 5, and 6	.75	.86
Ave. trials 1, 2, and 3 vs. Ave. trials 7, 8, and 9	.74	.85
Ave. trials 4, 5, and 6 vs. Ave. trials 7, 8, and 9	.73	.84
Ave. trials 1, 2, 3, and 4 vs. Ave. trials 5, 6, 7, and 8	.80	.89

* Reliability coefficient for a three-trial test.
** Reliability coefficient for a six-or eight-trial test.

When Dain and Hanson began their work with children and adolescents it was felt that a test of six trials probably would yield sufficient reliability for group comparisons of successive age samples. Table IV shows the coefficients of reliability they secured for age groups of 30 boys using the beams described earlier and the second fall-off procedure. These r's were obtained by correlating the three odd-trial and the three even-trial scores and correcting by the proper formula for a six-trial test.

TABLE IV

RELIABILITY OF THE BEAM-WALKING TEST FOR CHILDREN AND ADOLESCENTS IN THE DAIN AND HANSON STUDIES

Adolescents		*Children*	
Age	r	*Age*	r
18	.86	12	.79
17	.86	11	.89
16	.88	10	.83
15	.75	9	.85
14	.86	8	.86
13	.87	7	.89
		6	.85
13-18	.87	5	.88
		5-12	.93

BALANCE AMONG ADULTS

Since Whitney's testing procedure has been somewhat changed, there is no point in presenting his data for normative purposes. Out of a possible 40 points under his scoring scheme, the actual range on the first three trials was from 2 to 38 and on the last three from 8 to 38. While some persons made perfect trials, no one had three successive trials that were perfect. The means and medians practically coincided and the distributions were symmetrical.

Practice effect.—Table V shows the increase in mean score during the nine trials, three each on three different days. The greatest amount of gain was in the first three trials. The curve flattens out through trials 6 to 9, although it is entirely possible that considerably more improvement could occur. The writer has no idea that this is a measurement of "native ability." If the trials are averaged in three sets of three, critical ratios between these three sets of averages are as follows: 1-3 vs. 4-6, 6.7; 1-3 vs. 7-9, 10.9; 4-6 vs. 7-9, 3.8.

TABLE V

INCREASE OF MEAN SCORE THROUGH NINE TRIALS OF 100 ADULTS ON THE BEAM-WALKING TEST

Trial	*Mean*	*S. D.**
1	16.7	9.5
2	18.9	9.3
3	22.0	10.2
4	21.1	9.4
5	23.8	9.6
6	23.9	8.7
7	24.7	8.5
8	25.4	8.6
9	25.3	8.5
Average	22.1	7.1

*These standard deviations are larger than those in Table VII because of Whitney's plan of weighted scores which extended the range of scores considerably. The means likewise are not comparable because of the differences in scoring procedure.

Height, Weight, Age and Intelligence.—Other data were available for the 100 adult subjects which permitted correlating beam-walking test scores with height, weight, age, and scholastic aptitude as measured by the A.C.E. Psychological Examination. (Table VI).

TABLE VI

HEIGHT, WEIGHT, AGE, AND INTELLIGENCE TEST SCORES IN RELATION TO SCORES ON THE BEAM-WALKING TEST

N	*Variable*	*r*	*P.E.*
100	Ave. of trials 4, 5, 6 and Height	.22	.06
100	Same with Weight	.01	.07
100	Ave. of trials 7, 8, 9* and Age	.30	.06
39	Same with A.C.E. Test	.04	.11

* Whitney records no reason for using different sets of trials in his table.

THE DEVELOPMENT OF BALANCE FROM AGE 5 TO 18

Ideally, of course, genetic studies should carry the same population through a long period of observation. Lacking this opportunity,

one attempts to secure reasonable samplings and plot a pseudo-growth curve based upon group comparisons. For each age from 5 through 18, Dain and Hanson secured a sample of 30 boys. Any child past his fifth birthday but not yet six years old, was called a five-year-old, etc. The children were tested in two schools, the Boys' Club, and at the college, where 18 freshmen were included to complete the 18-year-old sample. The first testing was done at the Boys' Club where boys were taken randomly from the game rooms, dressing rooms, etc., with care than none was used just after heavy exercise. No systematic selection was made at the schools; children were sent out one by one until the sample was filled. The college men had already been tested as part of another project. The necessary number of 18-year-old students in this population was taken randomly from the roster. The samples of 30 cases per age are small, but were considered satisfactory to give a general picture of growth in the function of dynamic balance, which it is felt the beam-walking test measures.

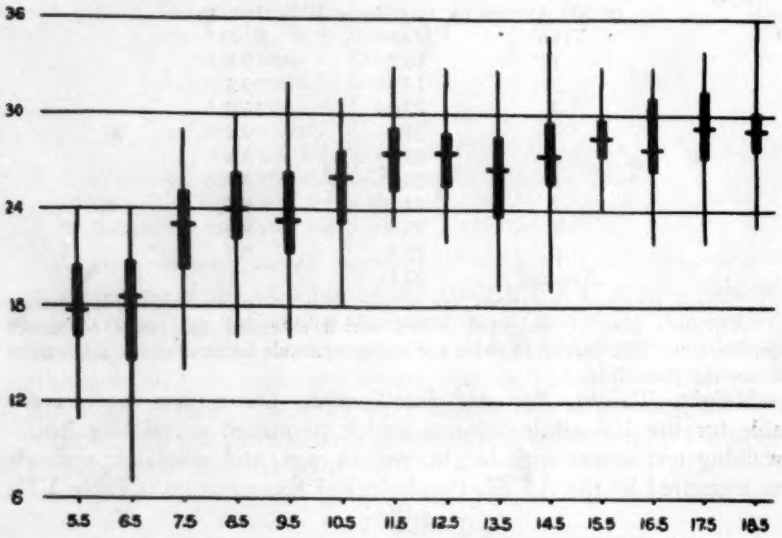

FIG. I. Age-by-age increases in scores on the Springfield Beam-Walking Test.

The data on the relation of age to dynamic balance are presented in Table VII and in Figure. 1. In Figure 1 the long slender line for each age gives the range of scores for the 30 boys; the wider band demarcates the range between Q3 and Q1, the middle fifty per-cent of the cases; and the small cross line denotes the median score.

The data and the figure suggest the presence of a typical growth curve and it is noticed that the balance function as measured by the beam-walking test seems to reach relative maturity rather early in

TABLE VII

PERFORMANCE OF EACH AGE GROUP ON THE SPRINGFIELD BEAM-WALKING TEST

Age	*Mean*	*S.D.*	*Q3*	*Median*	*Q1*
18	27.5	2.5	30.2	29.0	27.9
17	29.1	2.8	31.5	29.2	27.3
16	28.3	2.7	31.1	27.8	26.5
15	28.7	1.8	29.8	28.5	27.3
14	27.5	3.2	29.6	27.3	25.6
13	26.1	3.2	28.6	26.5	23.6
12	27.4	2.3	28.9	27.5	25.5
11	27.4	2.4	29.2	27.5	25.2
10	25.3	3.4	27.8	26.0	23.2
9	23.5	3.5	26.4	23.3	21.4
8	24.0	3.2	26.3	24.0	22.1
7	22.9	3.2	25.2	23.0	20.3
6	18.1	4.2	20.9	18.5	14.5
5	18.1	3.2	20.5	17.8	16.1

adolescence. The average again from age 5 to age 11 is about 10 points. The 17-year-olds are not much better than the 11 and 12-year-olds. Probably the curve actually would rise a little beyond 18 years; Whitney found a correlation of .30 between age and the test (as he administered it) among college men, most of whom were 18, 19, and 20 years old, with a few older.

While the growth curve shows general tendencies toward increases with age, one should not overlook the rather great range of performance within each age group. There are 7-year-olds who do as well as the average 15-year-old. The poorest 14-year-olds would also be in the lowest quarter of 7-year-olds. An educational implication is apparent; activity curricula which classify by age rather than by development may lump together children who are quite divergent in abilities. While the author would not hold for a strictly motor developmental classification without regard to age and mental development, this important variable must be taken into appropriate consideration.

Age, Height, and Weight.—Inasmuch as height and weight are so intimately related to age during the growing period, it is necessary to report their interrelationships. These are seen in Table VIII. Epecially for the lower ages, these data show that height and weight are related rather significantly to balance scores. In adolescent ages, height and weight are not as closely related to test scores. Therefore, in constructing norms for lower ages, it is necessary to take into account all three variables of growth. Samples will need to be obtained so that for a given age, the normative scores represent the performances of boys of that age who also are within certain limita-

TABLE VIII

ZERO ORDER AND PARTIAL CORRELATIONS TO SHOW RELATIONSHIP BETWEEN HEIGHT, WEIGHT, AND AGE AND THE BEAM-WALKING TEST

Variables	*Adolescents Ages 13-18*	*Children Ages 5-12*
	r	*r*
Height and Test	.15	.61
Weight and Test	.20	.59
Age and Test	.34	.47
Age and Height	.72	.88
Age and Weight	.75	.89
Height and Weight	.82	.93
Test and Age, with Height constant	.33	.18
Test and Age, with Weight constant	.30	.16
N	180	240

tions of height and weight. Doubtless the overlapping distributions of individual differences shown in Figure 1 are related to the height and weight variables.

Practice.—Table IX presents data for each trial for each age to enable a study of the effect of practice on performance.

TABLE IX

MEAN SCORE OF EACH AGE GROUP ON EACH OF THE SIX TRIALS ON THE BEAM-WALKING TEST, WITH THE MEDIAN OF THE MEANS TO SHOW THE GROSS PRACTICE EFFECT

Age	*1*	*2*	*3*	*4*	*5*	*6*
18	27.6	29.4	29.7	30.1	31.1	31.3
17	27.3	29.3	29.9	29.8	29.8	31.1
16	26.3	28.4	29.0	30.0	29.5	29.3
15	25.6	28.4	28.8	29.7	30.0	31.3
14	25.3	27.6	27.6	28.6	27.5	29.7
13	24.1	25.6	26.5	27.3	27.8	27.9
12	26.1	27.3	28.1	28.1	28.5	28.9
11	26.1	27.9	27.5	28.2	28.1	29.0
10	24.2	24.9	26.0	26.5	26.2	26.5
9	20.3	22.5	24.0	24.7	25.4	25.8
8	22.8	23.4	24.3	24.5	25.0	25.9
7	20.9	22.8	22.9	23.7	24.1	24.6
6	14.7	17.4	19.0	18.0	19.7	21.4
5	18.0	17.0	17.7	19.8	19.1	19.3
Median of above means	24.8	26.5	27.0	27.7	27.7	28.4

The writer is not ready at present to analyze satisfactorily the effect of practice on scores on the beam-walking test. Obviously one could teach most of these subjects to walk even the most narrow beam if proper motivation and opportunity for practice were given. However, on these tests reported, wherein six trials were given with no help as to the best techniques of walking the beams, the curves do

not rise very greatly except between trials one and two. The writer originally proposed to carry on a study to observe the individual differences in learning periods and also to relate the length of learning time to performance on the first six trials. Doubtless one could set up training procedures which would improve scores considerably Further research is needed to determine whether the rank order of the subjects would be altered.

VALIDITY AND OTHER INTERRELATIONS

No formal validation studies specifically revolving around the beam-walking test have been made, but the test, in various versions, has been included in several studies; its relation to other tests allegedly measuring balance is partly known.

In the general report referred to in the first footnote there are two studies bearing on validity. Wollenberger used the beam-walking test in his comparison of 139 students majoring in and 89 students not majoring in physical education. His version of the test was the same as that described herein as the final version of the test, except that all his men began on the 2-inch beam. He found a critical ratio of 3.02 between the curricular groups. These were adults and the difference observed is obviously due, to a considerable extent, to the greater previous experience in athletic activities on the part of the physical education men. In this case, the test was discriminative of two rather divergent curricular groups at the upper end of the developmental period.

Atkinson studied 50 basketball players. He used a different version of the test. His men had only two trials on five beams beginning with the 2-inch beam. They walked all five beams, stepping back on each time they failed. The number of errors was counted. The coefficient of reliability for these two trials, after correcting for length of test, was .91. The beam-walking test, as he gave it, correlated .23 with the criterion of basketball shooting under prescribed conditions. The reliability of his criterion was .87. This study was never extended as planned. The role this test might play with other and quite different variables in a multiple correlation with the criterion should have been carried out and the experiment repeated on a larger scale.

A sample of 85 freshmen was given the test as Atkinson gave it, except that four trials rather than two were attempted. The reliability for some reason dropped to .77. Another balance test, called the Balance Platform Test, was also administered. This test consisted of a wobbly platform which the subject was expected to keep as still as possible for a short period of time. A work adder accumulated his up-and-down motions around the fulcrum. This

test's reliability was .81 for four trials. The two balance tests—and scarcely anyone would argue that they were not balance tests—correlated .29. The "work" aspect of the balance platform was considerably greater; the men actually were tired after the four trials. In a factorial analysis in which the balance platform test entered but the beam-walking test did not, it was noted that the balance platform test did not "tie up" with any of the other gross and fine motor ability tests in the battery.

The beam-walking test and four other tests were given to 100 sophomores in the fall of 1939 with four trials and the second fall-off plan of scoring. The intercorrelations with two tests which were modifications of the Whipple steadiness test were .06 and .11. The correlation with scores on a model of the Koerth pursuit rotor was .27. The beam-walking test correlated with the Minnesota Rate of Manipulation Test as follows: placing, .05; turning, .04.

SUMMARY

The present studies have revived an interest which appeared earlier among physical educators and psychologists in the use of walking performances as measures of dynamic balance. The apparatus for the Springfield Beam-Walking Test is standardized and is applicable to the whole school range of ages. The procedure is set so that the test is simple to explain to the subject, the task is not foreign to him, and the situation does not provoke fear. The recommended method of scoring allows for reducing failures due to factors other than motor ability, and provides for a uniform set of scores usable through all ages. For all ages studied, the test is reasonably reliable. Individual differences are great, showing that this test is discriminating.

The preliminary genetic studies show that the typical curve of negative acceleration appears and that the leveling-off of the curve is quite apparent after the eleventh year. Part of the great range of scores in a given age can be explained as being due to the relationship of height and weight to balance and therefore norms must take these variables into consideration along with age. The effect of previous practice and the effect of practice during the trial are not determined yet with any precision.

The present report is a summary of the exploratory phase of a larger research project. The program of investigation included plans for further development of the techniques of measurement in this field of dynamic balance, to relate performances on the test of dynamic balance to performances on other tests of balance, dynamic and static, and as soon as possible, to make the work practical by relating test scores to such practical problems as the construction of curricula in physical education, the measurement of motor maturity for classifi-

cation purposes, and the prognosticating of athletic ability. Other uses in vocational psychology seem plausible.[9]

[9]Since the research reported herein was completed in 1940, another study using walking beams has appeared: S. R. Heath, Rail-walking performance as related to mental ages and etiological types among the mentally retarded. *Amer. J. Psychol.*, 1942: 55, 240-147. Also S. R. Heath. Clinical significance of motor defects, with military implications, *Amer. J. Psychol.*, 1944: 57, 482-499. His rail-walking test employs 4-, 2-, and 1-inch beams and the subjects walk barefooted. This test has been tried with deaf children: H. R. Myklebust, Significance of etiology in motor performance of deaf children with special reference to meningitis. *Amer. J. Psychol.*, 1946: 59, 249-258.

An Investigation of Certain Evolutionary Tendencies in the Female Human Structure

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(Submitted for publication, March, 1947)

THAT the human structure shows an almost infinite number of variations is a matter of common observation. It varies in the heaviness of the bony framework, in the trunk-leg proportions, in relative width of shoulders and pelvis, in the texture of the soft tissues, and in less obvious ways too numerous to mention. It has been observed that some human structures resemble those of the anthropoid apes either in part or in whole. For instance, relatively long arms, long forearms, large trunks combined with short legs, and long, narrow pelves—all characteristics of the anthropoid ape—have been observed (9). In their studies of the human female pelvis, Caldwell and Moloy observed four distinct types, one of which they designated the "anthropoid type," because of its resemblance to the pelvis of the anthropoid ape (1, 2). The writer, in examining some 5,000 college women, has similarly observed variations in the structure of the spinal column. Two types of deviation seem to stand out as distinct from what might be called the usual textbook type of spine, by which is meant the spine having a moderately convex thoracic curve and a moderately concave lumbar curve (3). One of the deviating types is characterized by a long posterior convexity extending down into the lumbar region, frequently all the way to the lumbo-sacral junction. The other is characterized by a shallow upper thoracic convexity and a long posterior concavity extending well up into the thoracic region. Since the concave lumbar curve is found only in man (5), the type of spine which is predominantly concave to the rear may be justifiably termed the "humanoid type" of spine, meaning a spine which shows a greater degree than usual of the human characteristic—a curve concave to the rear. The predominantly convex spine, on the other hand, being characteristic of the anthropoid ape, may be termed the "anthropoid type" of spine, if one uses the term as do Caldwell and Moloy. These spinal deviations have frequently been assumed to be postural or functional, but the fact that many of them do not respond to corrective measures led the writer to wonder whether perhaps they might not be inherited types of structure, reflecting evolutionary tendencies. The observations of C. H. McCloy (7) and of James F. Rogers (8) strengthened this opinion. Anthropologically, the "anthropoid" or

ape-like type of spine might be considered indicative of a regression in postural development, whereas the "humanoid" type might be considered as a more advanced stage of postural development.

Whether the so-called "anthropoid characteristics," such as long arms, large trunks, long narrow pelves, and predominantly convex spines, tend to appear together is not apparent from the literature studied. It would seem that the relationship between these structural characteristics has not been investigated. Because of a curiosity concerning this matter, and because of an interest in the various classifications of body build* in current use by anthropologists, orthopedists, psychologists, etc., the author was led to wonder whether the human physique might not also be classified according to its position on the evolutionary scale of development, and whether one would be justified in speaking of an "anthropoid build" or a "humanoid build."

PURPOSE

The purpose of the present study is two-fold: first, to discover whether there are measurable differences in the spines and other selected aspects of body proportions; and second, to discover whether the structural proportions characteristic of the anthropoid apes tend

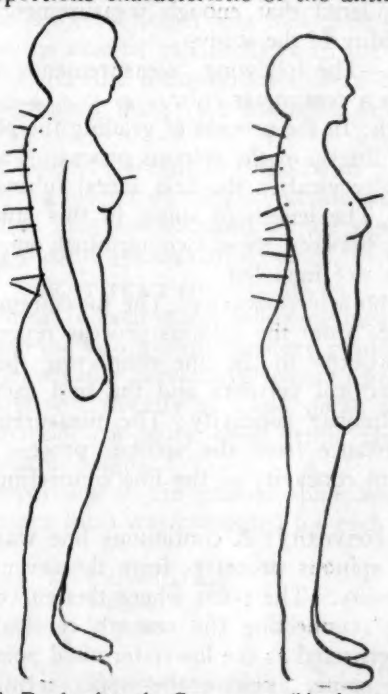

FIG. I (left). A Predominantly Convex, or "Anthropoid" Type of Spine.
FIG. II (right). A Predominantly Concave, or "Humanoid" Type of Spine.

*Linear and lateral; slender and stocky; leptosome and pyknic; masculine and feminine; endomorphic, mesomorphic, and ectomorphic.

to appear together in man, and if so, whether they appear with sufficient consistency to justify the proposing of an "anthropoid" and "humanoid" classification of body build. The scope of the present investigation is too limited to reveal any conclusive evidence on this matter. It should, however, be sufficient to reveal the *probable* existence, or non-existence, of some of the "anthropoid" and "humanoid" characteristics and their relationships.

PROCEDURE

Selection of subjects.—From 1,200 posture photographs of white college women 100 were selected subjectively by the investigator, fifty on the basis of predominance of a long posterior convexity of the spine, and fifty on the basis of predominance of a long posterior concavity. Except for weight, all of the measurements were obtained from the photographs. In the case of height, both the actual measurement of the subject and the measurement made on the photograph were used. The photographs had been previously taken and graded according to the Wellesley (MacEwan-Howe) Objective Method (6). Although the choice of measurements was necessarily limited by the fact that they were made from photographs, it was nevertheless considered that enough measurements were permitted to insure the validity of the study.

Measurements.—The following measurements were made on the photographs with a centimeter ruler.

1. Spinal length: In the process of grading the photographs by the objective method the tip of the spinous process of alternate vertebrae from the seventh cervical to the first sacral tuberosity, inclusive, is clearly marked. The length of spine, in this study, was taken as the measurement between these two terminal points. The cervical spine is therefore not included.

2. Depth of thoracic convexity: The measurement used was the horizontal distance from the spinous process representing the point of maximum convexity to the line connecting the spinous process of the seventh cervical vertebra and the first sacral tuberosity.

3. Depth of lumbar concavity: The measurement consisted of the horizontal distance from the spinous process representing the point of maximum concavity to the line connecting the two ends of the spine.

4. Length of convexity: A continuous line was drawn, connecting the adjacent spinous processes from the seventh cervical to the first sacral tuberosity. The point where this curved line intersected the straight line (connecting the seventh cervical and first sacral directly) was interpreted as the lower terminal point of the posterior convexity of the spine, likewise the upper terminal point of the posterior concavity. In extreme cases the length of the convexity coincided with the length of the spine, there being no concavity in these cases.

5. Chest depth: This was the horizontal distance from the proximal end of the chest pointer (representing the most prominent point of the sternum) to the curved line connecting the adjacent spinous processes of the vertebrae.

6. Arm length; upper arm and forearm length: The highest point of the shoulder was marked on the photograph. At the elbow, a line to separate the upper arm from the forearm was drawn from the apex of the posterior convexity of the bend of the elbow to the apex of the anterior concavity. The mid-point of this line was taken as the point-of-reference for the elbow. The wrist was marked in a similar manner, a line being drawn across the narrowest part of the wrist and the mid-point taken as the point-of-reference for the wrist. The distance from the shoulder point to the elbow point represented the length of the upper arm, and the distance from the elbow point to the wrist point, the length of the forearm. The sum of these two measurements represented the total arm length. A single measurement of the arm was not feasible because of the flexed position of the elbow. Likewise, because of the flexed position of the fingers, the length of the hand could not be measured.

Additional measurements, taken by other means, were as follows:

7. Height: The subject's height was measured on a stadiometer in inches (taken to the nearest half inch), with the subject standing in stocking feet. Later the measurements were converted to the scale of the photographed image for use with other photographic measurements.

8. Weight: The subject's weight was taken in pounds on spring balance scales, with the subject wearing an examining robe and socks.

9. Posture grade: This was obtained by the Wellesley Objective Method of grading posture photographs (6).

TREATMENT OF THE DATA

The arithmetic mean of each of the following measures was determined separately for the two groups: posture grade, height, weight, length of spine from seventh cervical vertebra to first sacral tuberosity, length of posterior convexity of spine, depth of posterior convexity, depth of posterior concavity, chest depth, arm length, upper-arm length and forearm length.

For further comparison of the convex spine and concave spine groups the significance ratio was computed for each of the following measurements:

$$\text{Posture grade}$$
$$\text{Height}$$
$$\text{Weight}$$
$$\text{Ponderal index} \left\{ \sqrt[3]{\frac{\text{Weight}}{\text{Height}}} \right.$$
$$\frac{\text{Convexity depth}}{\text{Spinal length}}$$

$$\frac{\text{Concavity depth}}{\text{Spinal length}}$$

$$\frac{\text{Convexity depth}}{\text{Convexity length}}$$

$$\frac{\text{Convexity length}}{\text{Spinal length}}$$

$$\frac{\text{Spinal length}}{\text{Height}}$$

$$\frac{\text{Chest depth}}{\text{Spinal length}}$$

$$\frac{\text{Arm length}}{\text{Spinal length}}$$

$$\frac{\text{Upper arm length}}{\text{Forearm length}}$$

With each group the $\frac{\text{Convexity length}}{\text{Spinal length}}$ ratio was correlated with the $\frac{\text{Convexity depth}}{\text{Spinal length}}$ ratio, and the $\frac{\text{Concavity length}}{\text{Spinal length}}$ ratio with the $\frac{\text{Concavity depth}}{\text{Spinal length}}$ ratio.

RESULTS

Table I gives the arithmetic means of each of the measurements used in the study.

TABLE I

MEAN VALUES OF MEASUREMENTS USED IN STUDY OF COLLEGE WOMEN HAVING "ANTHROPOID" AND "HUMANOID" TYPES OF SPINES.

	Means	
	"Anthropoid" Type	*"Humanoid" Type*
Lenth of spine	3.54 cm.	3.54 cm.
Depth of posterior convexity	.22 cm.	.08 cm.
Length of posterior convexity	2.79 cm.	1.48 cm.
Depth of posterior concavity	.06 cm.	.16 cm.
Length of posterior concavity	.75 cm.	2.06 cm.
Chest depth	1.50 cm.	1.40 cm.
Arm length	4.67 cm.	4.74 cm.
Upper arm length	2.62 cm.	2.64 cm.
Forearm length	2.05 cm.	2.10 cm.
Height (of subject)	64.94 in.	66.04 in.
Height (of photograph)	12.99 cm.	13.21 cm.
Weight	128.52 lbs.	128.16 lbs.
Posture grade	11.90 (C)	8.45 (B)

The mean, standard deviation, range and significance ratio for each of the measurements and ratios selected for comparison of the two groups are shown in Table II.

TABLE II

SIGNIFICANCE RATIOS FOR MEASUREMENTS OF PHYSICAL CHARACTERISTICS OF COLLEGE WOMEN SELECTED ON BASIS OF "ANTHROPOID" AND "HUMANOID" TYPES OF SPINES

	Mean and S. D.		*Range*		*Difference Between Means*	*Significance Ratio*
	"Anthropoid"	*"Humanoid"*	*"Anthropoid"*	*"Humanoid"*		
1. Posture grade	11.90 3.21	8.45 2.96	3.000- 18.000	.000- 15.000	3.45	5.59
2. Height	64.94 2.36	66.04 2.25	58.500- 70.000	61.500- 74.000	1.10	2.38
3. Weight	128.52 17.60	128.16 13.40	90.000-169.000	100.000-162.000	.360	0.12
4. Ponderal index	.078 .003	.076 .003	.070- .086	.070- .081	.002	3.40
5. Convexity depth / Spinal length	.063 .016	.022 .012	.031- .097	.000- .047	.041	14.44
6. Concavity depth / Spinal length	.017 .013	.046 .016	.000- .047	.015- .092	.029	10.32
7. Convexity depth / Convexity length	.080 .022	.048 .022	.039- .138	.000- .089	.032	7.51
8. Convexity length / Spinal length	.788 .086	.417 .111	.629- 1.000	.139- .667	.371	19.32
9. Spinal length / Height	.276 .012	.271 .009	.245- .295	.250- .290	.005	2.50
10. Chest depth / Spinal length	.426 .042	.395 .035	.333- .563	.324- .457	.031	0.05
11. Arm length / Spinal length	1.320 .074	1.340 .073	1.167- 1.485	1.180- 1.515	.020	1.36
12. Upper arm / Forearm	1.283 .081	1.261 .074	1.130- 1.500	1.080- 1.421	.022	1.42

Table III shows the coefficients of correlation and the standard deviations for the two pairs of ratios correlated within each group.

TABLE III

CORRELATION COEFFICIENTS.

		"Anthropoid"		*"Humanoid"*	
		r	*S.D.*	*r*	*S.D.*
$\frac{\text{Convexity length}}{\text{Spinal length}}$ and	$\frac{\text{Convexity depth}}{\text{Spinal length}}$	.217	.140	.688	.075
$\frac{\text{Concavity length}}{\text{Spinal length}}$ and	$\frac{\text{Concavity depth}}{\text{Spinal length}}$	.689	.074	.203	.135

INTERPRETATION AND DISCUSSION

1. Posture grade:

The difference between the means (11.9 — 8.45) and the significance ratio (5.59) suggest that there is a real difference in the posture of the two groups. The 11.9 mean for the "anthropoid" group is the equivalent of a C posture, and the 8.5 of the "humanoid" group, the equivalent of a B posture. The reader should not conclude, however, that individuals with the predominantly convex spine have poorer posture than those with the predominantly concave type. These results suggest, rather, that the posture experts tend to favor the "humanoid" type. This is not surprising because it looks more erect than the convex spine of the "anthropoid" type, and conforms with our aesthetic ideal of good posture. The "anthropoid" or convex type of spine has been looked upon with disfavor by orthopedists and physical educators because it suggests a slumping spine. Attention is called to the fact that the criteria used for the Wellesley Objective Grading Method consisted of the composite grades given by a group of orthopedists and physical educators to a large number of posture photographs. It seems reasonable to conclude that these experts considered the type of spine which is referred to in this study as "anthropoid" to be less desirable than the type herein referred to as "humanoid."

Since a single photograph of an individual does not indicate whether the predominantly convex spine is actually a "slumped" spine, or whether it is an inherited structure, the writer contends that there is at present no basis for assuming that one type of spine is superior to the other. There is no justification for evaluating spines on the basis of shape unless it can be demonstrated that one is mechanically or physiologically superior to the other. Lacking such evidence, the question should remain open until time proves the superiority of one type or the other. Possibly both the convex type and the concave type will disappear eventually, proving the superiority of the spine with a moderate thoracic and moderate lumbar curve.

2. Height:

The "humanoid" group shows a slight superiority in height, but the difference is not decisively significant. Before any deductions can be drawn regarding the respective heights of the "anthropoid" and "humanoid" types, a much larger number of subjects should be studied.

3. Weight:

There is no difference between the weight of the two. The "humanoid" group, however, shows less variability.

4. Ponderal index: $\left\{\frac{\sqrt[3]{\text{Weight}}}{\text{Height}}\right\}$

There is no appreciable difference between the two groups in this measure of body build.

5. $\frac{\text{Convexity depth}}{\text{Spinal length}}$

Taken with reference to spinal length, the depth of the posterior convexity of the spine shows a highly significant difference between the two groups. The mean for the "anthropoid" group is three times as great as the mean for the "humanoid" group, and the significance ratio is 14.44.

6. $\frac{\text{Concavity depth}}{\text{Spinal length}}$

Taken with reference to spinal length, the depth of the posterior concave curve of the spine in the "humanoid" group is nearly three times that of the "anthropoid" group. The difference is a significant one, as is shown by the significance ratio of 10.32.

7. $\frac{\text{Convexity depth}}{\text{Convexity length}}$

In relation to the length of the convexity, the convexity depth measurement shows a significant difference, the mean for the "anthropoid" group being more than one and a half times that of the "humanoid" group. The significance ratio is 7.51.

8. $\frac{\text{Convexity length}}{\text{Spinal length}}$

As a percentage of the total length of the spine, the length of the convexity is twice as great for the "anthropoid" group as for the "humanoid" group, and the significance ratio is 19.32. This highly significant difference is to be expected, since the basis of selecting the "anthropoid" photographs was a long posterior convexity.

9. $\frac{\text{Spinal length}}{\text{Height}}$

The means are almost the same for the two groups, indicating that the "anthropoid" type of spine is not necessarily accompanied by a long trunk, in spite of the fact that this is a characteristic of the anthropoid apes.

10. $\frac{\text{Chest depth}}{\text{Spinal length}}$

There is no significant difference between the two groups with respect to chest depth taken in relation to spinal length.

11. $\frac{\text{Arm length}}{\text{Spinal length}}$

Although long arms in relation to trunk length, and to total height, are also considered characteristic of the anthropoid apes, there is no difference at all between the two groups studied.

12. $\frac{\text{Upper arm}}{\text{Forearm}}$

There is no significant difference between the two groups in arm proportions.

13. Correlation between $\frac{\text{Convexity length}}{\text{Spinal length}}$ and $\frac{\text{Convexity depth}}{\text{Spinal length}}$

In the "anthropoid" group there is a low positive correlation ($r = .217$) between these two ratios, and in the "humanoid" group, a moderately high correlation ($r = .688$).

14. Correlation between $\frac{\text{Concavity length}}{\text{Spinal length}}$ and $\frac{\text{Concavity depth}}{\text{Spinal length}}$

In the "anthropoid" group there is a moderately high positive correlation ($r = .689$) between these two ratios, and in the "humanoid" group, a low one ($r = .203$).

In other words, although the "anthropoid" spine tends to have both a longer and a deeper posterior convexity than does the "humanoid" spine, there is but a slight degree of relationship between the length and depth of the convexity. One is not justified in saying, "The longer the convexity, the deeper." The portion of the spine showing a concave curve, however, does show a fairly close positive relationship between the depth and length. In regard to "anthropoid" spine, therefore, one may say, "The longer the posterior concavity, the deeper." Similarly, although the "humanoid" spine tends to have both a longer and a deeper posterior concavity than

does the "anthropoid," the relationship between the length and depth is slight. On the other hand, there is a fairly high degree of relationship between the length and depth of the posterior convexity.

SUMMARY AND CONCLUSIONS

Two groups of posture photographs of fifty each were selected from a large number of such photographs of college women, one group on the basis of a predominantly convex spine (called the "anthropoid" group), and the other on the basis of a predominantly concave spine (called the "humanoid" group). Measurements of spinal length, convexity and concavity depth, convexity length, chest depth, upper arm and forearm length were made on each photograph. These, plus the objective posture grades, and the height and weight measurements of the subjects, comprised the data used in the study. These measurements, and others derived from them, are analyzed with reference to differences between the two groups.

Because of the small scope of the study, no conclusive deductions can be drawn. The findings suggest, however, that significant measurable differences exist in the spines of the two groups. The "anthropoid" group tends to have relatively deeper and/or longer posterior convexities, and the "humanoid" group deeper and/or longer posterior concavities. The "humanoid" group tends to be slightly taller than the "anthropoid" group and to have a better posture grade according to the Wellesley Objective Method of grading posture photographs. With respect to chest depth, arm proportions, trunk-leg proportions, weight and ponderal index, there are no significant differences between the two groups. This suggests that "anthropoid" or ape-like characteristics such as long arms, long forearms, long trunk and deep chest are not necessarily associated with the "anthropoid" or ape-like type of spine. In conclusion, the findings of this study seem to indicate justification for using the terms "anthropoid spine" and "humanoid spine," but not for establishing a classification of body build based on "anthropoid" and "humanoid" characteristics.

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The Effect of Hard Laboratory Exercise on the Total and Differential Leucocyte Count of Young Women

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LEUCOCYTOSIS, or the rise of the white blood count, is a demonstrable physiologic phenomenon, and the phagocytic power of the white blood cells has long been known. Factors causing leucocytosis are infection, emotional stress, cyclic variations, mental and physical activity. The effect of exercise upon disease resistance is a controversial but important issue. Since exercise causes leucocytosis, the study of its effect upon this disease-resisting mechanism is of interest.

Leucocytosis was demonstrated in 1902 on Boston marathon runners by Larabee (8) and in 1904 by Hawks (5) following short bouts of severe exercise. Thirty seconds of standing running caused a rise of as many as 2,000 cells (4). The post-exercise counts continued to rise and then receded gradually. A fifty percent recovery was noted in less than five minutes for milder exercise, recovery being complete after fifteen minutes of rest. More vigorous running prolonged the rise and delayed the recovery for one half hour.

Egoroff (3) examined large numbers of subjects in moderate training and living a routine life after fatigue of varying degrees. The change in the white blood count reached a maximum in the post-exercise period, but in very prolonged exercise the blood picture attained a constancy during physical work. The blood picture of Egoroff was divided into three phases:

1. The mechanical, which occurs after a short run of from one to three kilometers, and which consists of a decrease in neutrophils and a rise in lymphocytes.

2. The neutrophilic, which is a rise in the neutrophils and a decrease in the lymphocytes and eosinophils.

3. The intoxication phase, which appears only after great strain, or in exercise of lesser strain in weaker subjects. This phase is

characterized by the appearance of *young* white cells and is associated with collapse.

The appearance of immature white cells is termed a "shift to the left." The neutrophilic phase of Egoroff was also reported by Isaacs and Gordon (6), and the intoxication phase by Westenrijk (15).

Tuttle (14) observed that leucocytosis varied directly with the heart rate and was dependent upon the severity of the exercise and training of the subject. Martin (9) reported a leucocytosis of from fifteen to forty percent after five minutes of severe exercise, with the greatest increase in lymphocytes. Reinisch (11) found leucocyte increases ranging from forty-four to two hundred and five percent in three subjects after severe exercise.

There is contradictory opinion as to the source of the white blood cells in leucocytosis following exercise. Dawson (2) quotes from Egoroff and Gaisbock who feel that the source of the white cells is the bone marrow. Schneider (12) states that an apparent leucocytosis may be due to concentration of the blood during exercise, while Tuttle (14) suggests that the leucocytes come from stagnant areas. Egoroff (3) states that only leucocytosis of the lowest degree can be due to a washing out of the stagnant areas.

PURPOSE

The purpose of this study was to observe the effects of hard laboratory exercise on the total and differential white blood count of normal, young, adult women.

METHODS

The subjects reported to the laboratory either in a post-absorptive state or after a very light lunch, in order to minimize the effects of digestion and absorption on the blood picture. Dressed for exercise, the subject reclined on a cot in a quiet, darkened room. Blood samples and smears were taken at thirty-minute intervals for the sixty-minute period of recumbency. Radial pulse rates, counting for a full minute, were recorded at five-minute intervals throughout the stabilization period. After stabilization the subject exercised on the electrodynamic brake bicycle ergometer (7), working at a rate of 0.162 horse power for a maximum of fifteen minutes, or for as long as the prescription could be maintained. Heart rates were taken by precordial auscultation for sixty seconds at five-minute intervals during the exercise.

Immediately after exercise the subject was assisted to the recumbent position. Blood samples, smears, and heart rates were taken at thirty-minute intervals for ninety minutes. The immediate post-exercise heart rate was recorded for five seconds only in order to minimize the rapidly declining pulse rate.

RESULTS

The subjects of the investigation were professional physical educators who were accustomed to severe exercise, were familiar with the problem, the experimental technics, and the laboratory procedure.

The length of the exercise periods ranged from thirteen to fifteen minutes with a mean of thirteen and eight-tenths minutes.

The Effect of Exercise on the Total Leucocyte Count.—The average of thirteen pre- and post-exercise total counts for each subject is shown in Table I. The average pre-exercise count for all subjects was 8,040 which is well within the normal range. The post-exercise averages were higher for each subject than the pre-exercise averages. The maximum increase was found in the *first* post-exercise sample, with an average count of 15,365 for all subjects, and a range of increase of from sixty-six and seven-tenths to one hundred and twenty percent.

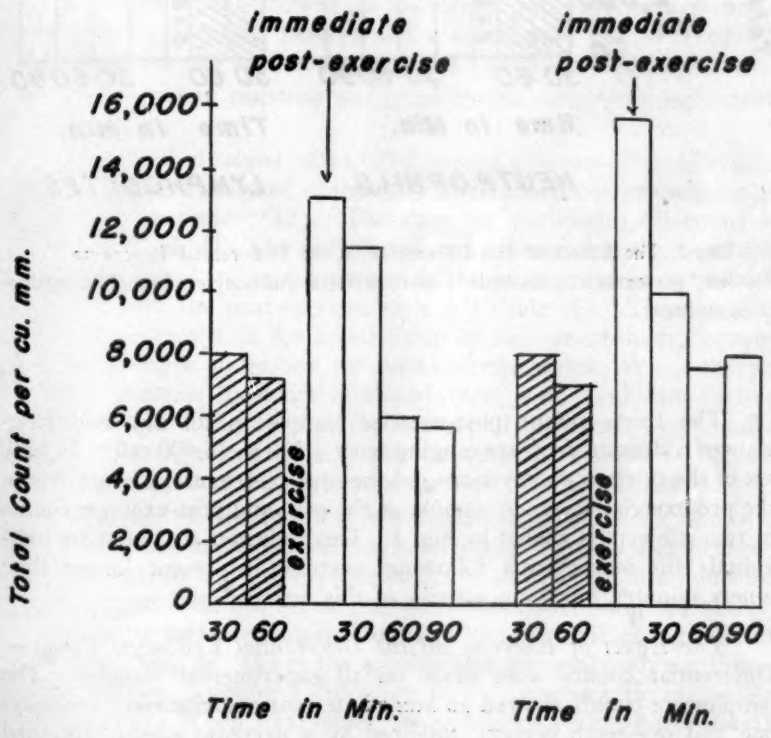

FIG. 1. The Effect of Hard Exercise on the Leucocyte Count. Shaded: pre-exercise; unshaded: post-exercise.

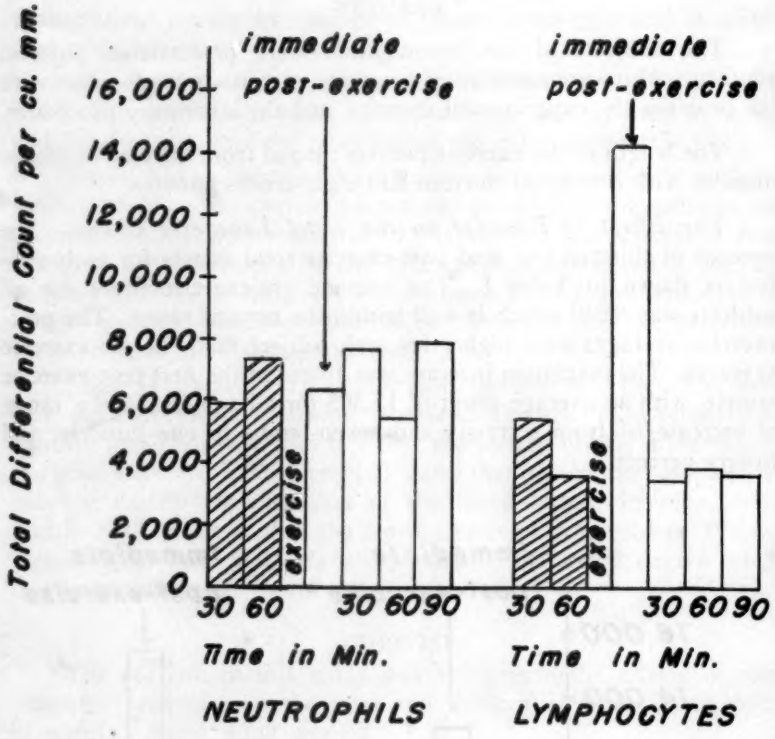

FIG. 2. The Effect of Hard Exercise on the Differential Leucocyte Count. Shaded: pre-exercise; unshaded: post-exercise (monocytes, basophils, eosinophils omitted).

The thirty-minute post-exercise sample in all but two cases showed a definite *decrease* ranging from 4,500 to 13,400 cells. In only six of the thirteen observations did the final post-exercise count rise to the pre-exercise level. A sample of the pre- and post-exercise counts in two subjects is shown in Fig. 1. This indicates that in some individuals the leucocytosis following exercise is present longer than ninety minutes following activity of this severity.

The Effect of Exercise on the Differential Leucocyte Count.— Differential counts were made on all experimental samples. The lymphocyte counts showed an immediate post-exercise *rise* of twenty-one and one-tenth percent, followed by a *decrease* which continued to the end of the post-exercise observations. The pre- and post-exercise counts of one subject are shown in Fig. 2.

TABLE I

DATA SHOWING EFFECT OF HARD LABORATORY EXERCISE ON DIFFERENTIAL LEUCOCYTE COUNTS

	Pre-Exercise		*Post-Exercise*			
Sub.	*Basal Range*	*Average*	*Immediate Post Exercise Range*	*Average*	*Average of all Post-Ex. Counts*	*Range % Inc.*
GR_3*	5,725 10,312 6,675	7,768	14,100-20,762	16,654	9,968	47.5-205.0
NO_3	9,150 7,325	8,130	14,012-18,000	15,758	10,030	69.5- 88.0
NW_3	11,000 4,875	9,196	12,650-19,585	15,920	10,698	67.6- 75.0
KR_2	7,787 8,650	6,331	11,987-14,862	13,424	7,935	82.6-141.8
MM_2	8,900	8,775	13,575-16,562	15,068	9,702	66.9-100.2
Group Average		8,040	13,265-17,554	15,365	9,666	66.7-120.0

* Number of experimental bouts.

The neutrophils showed an immediate post-exercise *decrease* of fifteen and four-tenths percent and a subsequent rise of five-tenths percent at the end of the post-exercise recumbency period.

No consistent response was given by the monocytes, eosinophils, or basophils.

Statistical Analysis of the Differential Count.—The differential count data were analyzed statistically by the Snedecor formula for the analysis of variance (13). The data for the neutrophil count are shown in Table II. The only significant difference in the neutrophil count was found in the comparison of the average pre-exercise slides 1 and 2 with the post-exercise slide 3 (Table II). There was no significance shown in the relationship of the mean square between the pre-exercise slides and the post-exercise slides. When the pre- and post-exercise slides are combined, there is no significant variance shown, which indicates that the neutrophil responses were similar. There is no significant relationship between the slides and the subjects, showing that the subjects responded in a like manner.

Analysis of variance for the lymphocyte counts is shown in Table III. As in the case of the neutrophils, the only significance is shown between the pre-exercise slides 1 and 2 and the immediate post-exercise slide 3. When the total slides are combined there is a significant variance, showing definite lymphocyctic changes resulting from exercise. When the subject data are analyzed, significance is also shown, denoting a difference in the lymphocyctic response of the subjects. When total slides are compared with subject data no variance is shown, indicating that the subjects tended to respond in a like manner to experimentation.

TABLE II

THE ANALYSIS OF VARIANCE OF NEUTROPHIL COUNT CHANGES PRODUCED BY HARD LABORATORY EXERCISE IN FIVE YOUNG WOMEN

Slides	*Degree of Freedom*	*Sums of Squares*	*Mean Square*	*F**
1 vs 2	1	.09	.09	<1.00
1 2 vs 3	1	634.69	634.69	6.00**
1 2 vs 4	1	6.49	6.49	<1.00
1 2 vs 5	1	11.92	11.92	<1.00
1 2 vs 6	1	83.07	83.07	<1.00
Total Slides	5	1046.83	209.36	1.98
Subjects	4	1067.08	266.77	2.52
Slides x Subjects	20	1521.73	76.09	<1.00
Error	48	5077.04	105.77	
Total	77	8712.68		

Pre-exercise slides: 1 and 2.
Post-exercise slides: 3, 4, 5, and 6.
* Degree of freedom.
** Significant.

TABLE III

THE ANALYSIS OF VARIANCE OF THE LYMPHOCYTE COUNT CHANGES PRODUCED BY HARD LABORATORY EXERCISE IN FIVE YOUNG WOMEN

Slides	*Degree of Freedom*	*Sums of Squares*	*Mean Square*	*F**
1 vs 2	1	57.02	57.02	<1.00
1 2 vs 3	1	1030.41	1030.41	8.72**
1 2 vs 4	1	48.49	48.49	<1.00
1 2 vs 5	1	8.34	8.34	<1.00
1 2 vs 6	1	73.08	73.08	<1.00
Total Slides	5	1606.41	321.28	2.72***
Subjects	4	850.05	212.51	2.88***
Slides x Subjects	20	1373.65	68.68	<1.00
Error	48	5670.41	118.13	
Total	77	8308.61		

Pre-exercise slides: 1 and 2.
Post-exercise slides: 3, 4, 5, and 6.
* Degree of Freedom.
** Highly significant.
*** Significant.

DISCUSSION

The post-exercise rise in lymphocytes and the decrease in neutrophils are in agreement with the work of other investigators.

Three decreases in cell numbers were observed in this study; the first in the immediate post-exercise neutrophil count, the second in the thirty-minute post-exercise *total* count, and the third in the

thirty-, sixty-, and ninety-minute post-exercise lymphocyte count. The literature apparently contains no explanation to account for these decreases, but several suggestions may be offered.

The application of heat to a body part attracts leucocytes in large numbers to the capillaries, from which neutrophils immediately start to migrate (1). Since heat attracts leucocytes to the capillaries, and muscular exercise causes a rise in temperature, the decrease in leucocytes may be due to the migration of the actively ameboid neutrophils into body tissues. Heat also increases capillary permeability which would facilitate neutrophil migration. Destruction of cells, due to increased circulatory rate and blood pressure changes, might also account in part for the decrease in neutrophils.

The immediate post-exercise lymphocyte increase may be more apparent than real due to the decrease in neutrophils, since the lymphocytes are not actively ameboid. This may also be due to the increase in blood concentration resulting from water loss due to sweating and the infiltration of water into active muscles. Therefore, the thirty-, sixty-, and ninety-minute post-exercise neutrophilic *increase* and lymphocyctic *decrease* suggest a redistribution of cells with the return of neutrophils from the body tissue due to physiochemical changes and a lowering of body temperature following exercise. Menkin (10) postulates a leucopenic factor. Exercise may be a stimulus for the release of this factor.

SUMMARY AND CONCLUSIONS

The effect of hard laboratory exercise on the total and differential leucocyte counts of five normal, young women was studied.

1. Hard laboratory exercise of short duration produces leucocytosis in normal, young, adult women.
2. Post-exercise leucocytosis is repeatable.
3. Post-exercise leucocytosis may be followed by neutrophilic leucopenia, with a subsequent return to pre-exercise level.
4. There is a highly significant increase in lymphocytes and a significant decrease in neutrophils in the immediate post-exercise differential counts.
5. The mechanism of exercise leucopenia is unknown.

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A Study of Certain Factors in Their Relation to the Play of Children

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MODERN philosophers and educational writers have emphasized play as essential to the growing child both in the development of a strong physique and the effecting of a satisfactory personality and social adjustment. In addition, it generally has been believed that play is essential for the expression of natural impulses characteristic to human beings as well as to the majority of mammals. The general recognition of play as a basic phenomenon of human behavior has resulted in considerable investigation. This investigation attempts to shed some light on the role of strength and motor ability factors in relation to children's play.

PROBLEM AND DATA

The problem of this study is to find the relationship between two play factors, frequency and duration of time devoted to play, and the following measures: (1) Strength Index, (2) Physical Fitness Index, (3) General Motor Capacity, (4) Motor Quotient, (5) Mental Age, (6) Intelligence Quotient, (7) Chronological Age, (8) Weight, (9) Height, (10) Classification Index, and (11) Socio-Economic Status.

This investigation was conducted in the J. D. Pierce Junior High School, Grosse Pointe, Michigan. The subjects of the study were 348 boys and 348 girls in attendance during the school year. Grosse Pointe is contiguous to Detroit, Michigan, along the shore of Lake St. Clair.

REVIEW OF LITERATURE

Since 1900, there has been considerable interest and research on the role of the play of children. Although many investigations have been published about the different aspects of play behavior, little work has been done on the play of children with different degrees of muscular strength and large-muscle coordinations. A complete review of the literature is impossible due to publishing limitations. However, citations of related play studies will be mentioned without a critical analysis of the literature.

The literature reveals certain differences in the quantitative and qualitative play behavior among children who have unequal mental abilities (36,12,40,29,2,23,25,32,34).

Play activities vary in a general way with age stratification (25,19,10,24). The literature indicates differences in play behavior of the sexes, in the way activities are played, and the nature of the play activities (36,5,25,3,9). Various studies of personality and play have been conducted (21,22,7,39). There is evidence that forces exerted by environmental factors influence play of children (9,18,25). Lehman's and Witty's (25) contrast of negro and white children is the only significant information on race differences. Somatic features were investigated by Clevett (6).

In order to avoid confusion, definitions of certain terms used in this study are given. The term "strength-motor tests" is used here as a convenient and practical phrase to cover a number of tests which have often been classified under diverse rubrics, such as Strength Index, Physical Fitness Index, General Motor Capacity, and Motor Quotient. These tests are measures of muscular strength and large-muscle coordination of children.

Play is a subjective phenomenon. Its complexity escapes complete definition. Therefore, in this study, play activities are activities which the children reported participation in and were considered by them to be their play.

Versatility or frequency of play refers to the number of play activities in which the children reported participation. Duration or allocation of time devoted to play, or play time, refers to the number of minutes in which children reported participation in their play activities.

THE SELECTION AND ADMINISTRATION OF TESTS

Criteria for both form and content were considered in the selection of tests to measure the strength-motor performance of junior high school pupils. These tests had to be sufficiently interesting to maintain motivation. With regard to content, they had to sample many aspects of strength-motor performance through functions which were not to a great degree affected by differential practice among the subjects tested. The specific content and the administration of the Modified Intercollegiate Strength Test and the General Motor Capacity Test battery were in accordance with the published experimental work of McCloy (30).

Terman's Group Test of Mental Ability, Form A, was employed to obtain measures of mental attainment. The Sims Score Card for Socio-Economic Status, Form C, was used to determine the socio-economic status of the pupils.

Realization of the need for a technique to determine the play activities of the children of this particular community led to an attempt to discover, insofar as it was possible to do so, in just what play activities children participated and also how many minutes were allocated to their play. The play questionnaire employed in this study

was patterned after Lehman's Play Quiz (25) but it was altered and expanded to meet the conditions of the community and the particular study. Every precaution was taken to employ adequate safeguards to avoid the collection of spurious data.

TABLE I

THE RELIABILITY OF THE NUMBER OF ACTIVITIES CHECKED UPON THE PLAY QUESTIONNAIRE AS REVEALED BY THE CONSISTENCY OF RESPONSES OF THE STUDENTS

Index	*Correlation*
Variable 12	.723 ∓ .01
Variable 13	.844 ∓ .01
Variable 23	.734 ∓ .01
Variable 45	.670 ∓ .02
Variable 46	.808 ∓ .01
Variable 56	.754 ∓ .01

Variable 1—Number of Activities checked by Boys, Sept.
Variable 2—Number of Activities checked by Boys, Feb.
Variable 3—Number of Activities checked by Boys, May
Variable 4—Number of Activities checked by Girls, Sept.
Variable 5—Number of Activities checked by Girls, Feb.
Variable 6—Number of Activities checked by Girls, May.

TABLE II

THE RELIABILITY OF THE ALLOCATION OF TIME DEVOTED TO PLAY ACTIVITIES AS REVEALED BY THE CONSISTENCY OF RESPONSES OF THE STUDENTS

Correlation	*Correlation*
Variable 12	.373 ∓ .03
Variable 13	.725 ∓ .01
Variable 23	.417 ∓ .02
Variable 45	.571 ∓ .02
Variable 46	.743 ∓ .01
Variable 56	.607 ∓ .02

Variable 1—Allocation of Time Devoted to Play by Boys, Sept.
Variable 2—Allocation of Time Devoted to Play by Boys, Feb.
Variable 3—Allocation of Time Devoted to Play by Boys, May
Variable 4—Allocation of Time Devoted to Play by Girls, Sept.
Variable 5—Allocation of Time Devoted to Play by Girls, Feb.
Variable 6—Allocation of Time Devoted to Play by Girls, May.

A comprehensive list of one hundred and fifty play activities was employed to ascertain the frequency and duration of time devoted to play in which the students engaged during the week of the investigation. The students recorded daily their play activities on this questionnaire. The play questionnaire was administered at three different intervals during the school year. The administration of the play questionnaire on three different occasions served to prevent unreliable data in reference to non-seasonal activities. Moreover, unusual conditions which might attend one administration of the test were partially minimized by three separate investigations and under ordinary conditions and errors would distribute themselves at random, so they would tend to cancel each other for the group as a whole. Seasonal, climatic, and various individual conditions make it extremely difficult to obtain high reliabilities for the play ques-

tionnaire (Tables I, II). Nevertheless, the reliabilities are generally consistent and high for this type of questionnaire technique. This study divides the test data into two separate groups constituting one standard deviation or more from the mean. Individuals who exhibited strength-motor performance and play pursuits in conjunction with other measures in this investigation to such pronounced extent as to one or the other of these groups were considered. The procedure of dividing the total group in said manner permits the obtaining of a correlation coefficient as well as an analysis of the type and extent of play differences of each group. A study of these play differences will be published later.

The tetrachoric correlation from widespread classes (33) was employed. The correlation thus derived will be equivalent to the Pearson Product Moment. The Chi-Square was employed for testing the frequency distributions from divergence from normality. The obtained probability values were .94 or better for all distributions. The assumption was fully met and the tetrachoric correlation employed. The formulae for the tetrachoric correlation for widespread classes is as follows:

$$\frac{a}{N} = \frac{1}{2\pi} \int_{k_2}^{\infty} \int_{h}^{\infty} e^{-\frac{1}{2}(x^2 + y^2)} \, dx \, dy + Z_{k_2} Z_h S$$

In an examination of the Intercorrelation Tables III and IV, a sex difference is apparent in the magnitude of the correlations between the Strength Index and factors of play, and also the general consistency of size of the correlations between the Strength Index and the remaining measures in this study. Correlations between the Strength Index for boys (Table III), frequency of play, and play time showed marked correspondence of .54 and .53 respectively, between these variates. The results for girls between these same variates are higher. The versatility of play, and the time devoted to play show identical correlations, .62, with the Strength Index (Table IV). According to Garrett (11) the interpretation of the correlation in terms of verbal description denotes a "substantial or marked relationship." Significant correlations are noted between the Strength Index and the two play factors for both sexes. To be reasonably sure at least some degree of correlation greater than zero is present. Garrett states, "an obtained r should be four times its P.E."

The Strength Index has a high degree of association with physical structure (age, height, weight) since the influence of these factors is the general manifestation of certain basic considerations in a person's ability to develop power. While weight has a correlation of .82 with Strength Index for girls, age and height have a somewhat

TABLE III
INTERCORRELATION TABLE FOR BOYS

	Strength Index	Physical Fitness Index	General Motor Capacity	Motor Quotient	Frequency of Play Activities	Time Devoted To Play	Mental Age	Intelligence Quotient	Socio-Economic Status	Classification Index	Chronological Age	Weight	Height
Strength Index	..	.72	.77	.25	.54	.53	.31	.26	.15	.74	.71	.82	.71
Physical Fitness Index	..	..	.59	.64	.49	.21	.33	.13	.11	.10	.20	.23	.12
General Motor Capacity	..	..	..	.73	.64	.44	.54	.28	.27	.77	.70	.72	.65
Motor Quotient	..	..	..	..	.53	.36	.45	.23	.16	.12	.44	.17	.37
Number of Play Activities	..	..	..	..	..	.77	.48	.30	.29	.27	.39	.17	.24
Time Devoted to Play	..	..	..	..	..	..	.45	.19	.32	.32	.56	.20	.14
Mental Age	..	..	..	..	..	..	..	.74	.56	.28	.50	.34	.34
Intelligence Quotient	..	..	..	..	..	..	..	..	.45	.43	.46	.14	.16
Socio-Economic Status	..	..	..	..	..	..	..	..	..	.23	.20	.29	.30
Classification Index	..	..	..	..	..	..	..	..	..	..	.75	.81	.43
Chronological Age	..	..	..	..	..	..	..	..	..	..	..	.63	.66
Weight	..	..	..	..	..	..	..	..	..	..	..	..	.73
Height	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE IV

INTERCORRELATION TABLE FOR GIRLS

	Strength Index	Physical Fitness Index	General Motor Capacity	Motor Quotient	Frequency of Play Activities	Time Devoted To Play	Mental Age	Intelligence Quotient	Socio-Economic Status	Chronological Age	Weight	Height
Strength Index	..	.76	.34	.23	.62	.62	.38	.24	.26	.40	.82	.59
Physical Fitness Index	..	..	.46	.41	.52	.38	.48	.22	.10	.09	.27	.23
General Motor Capacity	..	..	..	.79	.34	.44	.63	.15	.23	.43	.41	.11
Motor Quotient	..	..	..	..	.23	.40	.52	.24	.08	.42	.18	.16
Number of Play Activities	..	..	..	..	..	.76	.49	.29	.31	.25	.22	.30
Time Devoted to Play	..	..	..	..	..	..	.55	.11	.36	.59	.42	.13
Mental Age	..	..	..	..	..	..	..	.72	.64	.37	.31	.30
Intelligence Quotient	..	..	..	..	..	..	..	..	.39.	.50	.13	.17
Socio-Economic Status	..	..	..	..	..	..	..	..	..	.20	.26	.36
Chronological Age	..	..	..	..	..	..	..	..	..	..	.49	.61
Weight	..	..	..	..	..	..	..	..	..	..	..	.66
Height	..	..	..	..	..	..	..	..	..	..	..	..

lower association. The correlation of age and height with the Strength Index for girls is .40 and .59, respectively.

The intercorrelations between intelligence and socio-economic factors and the Strength Index are positive, but low for the sexes. The degree of communality between intelligence and the Strength Index, in general, is slightly higher than the relationship of Strength Index and socio-economic status.

The Physical Fitness Index is an index of strength relative to age, size, and sex of the individual. In general, the pattern of the intercorrelations between the Physical Fitness Index and the variables of play, intelligence, socio-economic factors, and measures of size and maturity show a lower covariance than these same variates have with the Strength Index for the sexes. It should be noted, however, that the one exception to this general pattern of decreasing magnitude of correlations is the slightly higher association between mental age and the Physical Fitness Index. For boys, these two factors correlate .33. For girls an almost identical correlation (.31) between the Strength Index and mental age is noted. For girls, this same relationship between strength performances (Physical Fitness Index and Strength Index) and mental age is .48 and .38, respectively.

Substantial and consistent decreases are noted in the covariation between the Physical Fitness Index and indices of body structure (age, height, and weight), of both sexes. However, in the case of boys, the decreasing size of correlations is greater in the factors of height and chronological age than are these same two factors in girls.

Within the range investigated, sizable differences between the sexes are evident in the correlations between General Motor Capacity and the play pursuits of children. Correlations between General Motor Capacity and play versatility are .65 for boys and .34 for girls. However, the time devoted to play and the General Motor Capacity show identical correlations, .44, for boys and girls. The intercorrelation tables reveal that the General Motor Capacity test has a higher relationship with the frequency of play, .64, than the Strength Index has with this same play variable, .53, in boys. The correlation between the General Motor Capacity and the time devoted to play for boys is slightly lower, .44, than the degree of relationship, .53, which exists between the Strength Index and play time.

For girls, the degree of relationship between the General Motor Capacity and the two play factors, versatility of play and play time, is of decidedly lower order than the same correlations between the same factor for boys. Correlations of .34 and .44 between the Gen-

eral Motor Capacity and the play factors, versatility of play and play time, respectively, are found.

Factors of size and maturity are closely associated in boys with the General Motor Capacity. Correlations of the same magnitude between the General Motor Capacity and factors of size and maturity are not so pronounced in girls. Since the General Motor Capacity is not highly related to the two play variables (play frequency and play time) in girls, the degree of relationship is evidently influenced by different factors in girls than in boys. A closer analysis of the intercorrelation tables reveals conspicuous differences in the relationship of physical characteristics (weight, height, and strength) to the General Motor Capacity. It seems reasonable, as a partial explanation, to assume that greater skeletal maturity should facilitate motor performance by providing a strong framework with maximum length and breadth of structure. This seems to be the case in boys where the covariances between weight, height, Classification Index, and Strength Index have correlations of .71 or better. In general, intelligence and socio-economic factors manifest a low relationship with the General Motor Capacity, except mental age for both sexes.

The Motor Quotient is purely a relative capacity score, indicating the quantitative relationship between an individual's capacity and the average capacity for boys or girls of his age and size. For both sexes, the correlation constellations of variates (height, weight, intelligence quotient, mental age, and socio-economic status) in this investigation between the Motor Quotient and the Physical Fitness Index (also a quotient) exhibit approximately the same magnitude and pattern of correspondence. Correlations are all positive, with generally low covariance between the Motor Quotient and factors of height, weight, socio-economic status, and intelligence quotient. The Motor Quotient exhibits a higher degree of correspondence with mental age, chronological age, Physical Fitness Index, and the two play factors than with any other single factor. Versatility of play and time devoted to play correlate with the Motor Quotient .53 and .36 respectively, for boys, and .23 and .40 for girls respectively. For the sexes, correlations of .42 to .52 are found between mental age, chronological age, and the Motor Quotient.

Differences in the correlation pattern between sexes in measures of intelligence, socio-economic status, and the play pursuits of children are not appreciably large. Of the two measures of intelligence, mental age has the greater magnitude of association with the factors of play: play frequency and time devoted to play. Mental age exhibits a correlation of .48 and .45 with versatility of play and time devoted to play, respectively, for boys. Correlations of approxi-

mately the same magnitude, .49 and .55 respectively, are obtained between the same sets of measures for girls. Correlations of .30 and .29 for boys and girls, respectively, are noted between the intelligence quotient and frequency of activities engaged in play. There is a noticeable difference in the size of the correlations .19 and .11 between intelligence quotient and the allocation of time devoted to their activities for boys and girls, respectively.

Disregarding certain measures of strength-motor performances, chronological age and mental age have the highest degree of relationship with the two play factors. Chronological age and the boys' allocation of time devoted to play have the highest degree of relationship, .56. In girls, the Strength Index has a slightly higher correlation, .62, than chronological age, .59, with time devoted to play. It is noticed that the order of the relationship is slightly higher in girls than in boys. Chronological age has consistently higher correlations with the play factors than mental age with one exception, in boys, between chronological age and versatility of play. Mental age has lower correlations with the factors of play than the Strength Index. Correlations of .48 and .45, and .49 and .55, boys and girls, respectively, are obtained between mental age, versatility of play, and play time respectively.

Despite the relationship which is found between intelligence and socio-economic status, a lower magnitude of association between socio-economic status and the factors of play for both sexes is obtained. The magnitude of the correlations is slight, but consistent within the pattern of relationships. Correlations from .29 to .36 are present between socio-economic status and the two measures of play for sexes. Of the two play measures, time devoted to play correlates to a slightly higher extent in the sexes with socio-economic status.

The intercorrelation matrices reveal similar correlational patterns of size and maturity with respect to their degrees of covariance with the versatility of play with children. Chronological age, height, and weight correlate rather low with play versatility for both sexes. Correlations of .25, 22, and .30 are found between chronological age, weight, and height, respectively, for girls. Chronological age, height, and weight for boys positively correlates .39, .17, and .24 with play versatility. The Classification Index correlates .27 with frequency of play. All correlations of measures of size and maturity are generally low, except for chronological age with time devoted to play activities, which is .56 and .59 for boys and girls, respectively.

SUMMARY

1. The absolute strength measure (Strength Index) for boys correlated .54 and .53 with frequency of participation and participa-

tion-time, respectively. For girls, the relationship between the Strength Index and frequency of participation, and play time showed identical correlations of .62. The absolute motor measure (General Motor Capacity) for boys correlated .64 and .44 with frequency of participation and participation-time, respectively. For girls frequency of participation and participation-time correlated .34 and .44 with General Motor Capacity, respectively.

2. The relative strength measure (Physical Fitness Index) for boys correlated .49 and .21 with frequency of participation and participation-time, respectively. For girls, frequency of participation and play time correlated .52 and .38 with the Physical Fitness Index, respectively. The Motor Quotient for boys correlated .53 and .36 with frequency of participation and participation-time, respectively. For girls, the relationships between the Motor Quotient test and frequency of participation, and play time were .23 and .40 respectively.

3. Of the remaining variables, (intelligence quotient, mental age, chronological age, socio-economic status, weight, and height) mental age and chronological age for boys and mental age for girls had the highest correlation with frequency of participation and the amount of time devoted to play. For both sexes, allocation of time devoted to play correlated higher with chronological age and mental age than with the Physical Fitness Index or Motor Quotient.

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A Comparative Study of Structure and Function of Normal, Pronated, and Painful Feet Among Children.

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CONSIDERABLE conflict is found in the literature on statics and function of the lower extremity. The criteria reported seem to have been established largely on empirical bases. Pronation (inward rolling of the ankles with resulting disalignment of the feet and legs) remains the most widely accepted criterion of foot weakness and strain. Fifty to sixty percent of the child population shows pronation to a greater or lesser degree. However, functional foot complaints are relatively uncommon among children and very common among adults. If all pronation seen among children of school age is indicative of foot strain a gigantic remedial problem is present. If it is not pathological in all cases, which cases are in need of correction or remedial care? In the interests of efficiency and economy in prevention of foot disability there is need of valid diagnostic criteria of potentially painful feet in the presymptomatic stage. Toward this end a comparative study of normal, pronated, and painful feet among children was undertaken.

The present study investigated six areas of foot structure and function, including (1) foot statics, (2) foot morphology, (3) tenderness areas on the sole of the foot, (4) flexibility of the lower extremity and trunk, (5) foot strength, and (6) alignment of the feet and legs. Toward this end an analysis of thirty-five anthropometric and x-ray variables were studied with three groups of children between eight and fourteen years of age. One group of seventy-five children was judged to have symptomless, normal, or well aligned feet and legs. The second group of fifty-two children showed symptomless, markedly weak or pronated alignment. The third group of fifty-one children reported persistent symptoms typical of functional foot strain. Fifty-seven percent of this third group showed normal alignment or only very slight pronation, eight percent showed moderate pronation, and thirty-seven percent showed marked pronation.

VARIABLES STUDIED

1. *Angle of Stance* (Figure 1).—This angle, described by Morton (12), is the angle between the mid-longitudinal axes of the two feet, measured from the two lines H-T, which connect the center of the contact area of the heel with the cleft between the second and third toes. In this study the angle was read

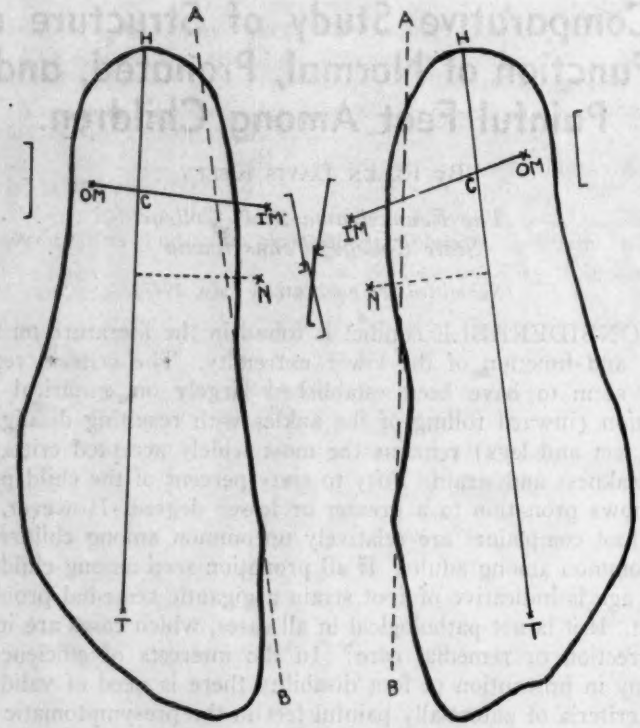

Fig. 1.

from a foot tracing, in which the foot position represented an average of three positions of the feet assumed by the child at the completion of three trials of approximately ten steps of walking in place.

2. *Angle of Foot to Ankle* (Figure 1, Angle T-C-IM).—This variable suggested by Morton in personal conference with the writer, was the angle formed by a line connecting the inner and outer malleoli and a line representing the mid-longitudinal axis of the foot. In this study the location of the two malleoli was determined by use of a small caliper. With the base of the caliper in contact with the table and the movable blade against the malleolus, the base was shifted until the blade formed a right angle with an imaginary line connecting the two malleoli. The base of the caliper was traced on the paper, and the exact lateral projection of the malleolus later diagrammed by measuring in from the base the distance of the length of the caliper blade (Figure 2).

3. *Ankle Overhang* (Figure 1, Ratio IM-C : C-OM).—This variable, also suggested by Morton, was the ratio between the amount of the inner and the outer overhang of the intermalleolar diameter from the mid-longitudinal axis of the foot.

4. *Navicular Overhang* (Figure 1, N).—The perpendicular distance of the most medial projection of the navicular from the mid-longitudinal axis of the foot was measured from the foot tracing (Figure 3). This measurement was then divided by the width of the foot, in order that the measurement not be a function of the size of the foot. The width of each foot was measured with

Left to right:
Fig. 2, 3, 4.

Left: Fig 5;
right: Fig. 6.

calipers from the x-ray as the distance between the most medial projection of the first cuneiform and the most lateral projection of the cuboid when the caliper blades were held parallel to the longitudinal axis of the foot.

5. *Depression of the Arch from Sitting to Standing Plus ¼ Body Weight.*—This measurement of arch depression consisted of the difference between the average height of the lowest projection of the navicular with the subject sitting and the subject standing and holding a weight equal to one fourth of his own body weight in both hands behind him. This depression was divided by the length of the foot, measured from the foot tracing, in order that the score not be a function of the length of the foot.

6. *Depression of the Arch from Standing to Standing Plus ¼ Body Weight.*—This measurement of arch depression consisted of the difference between the average heights of the lowest projection of the navicular with the subject standing and standing holding the weight, as described under variable 5.

7. *Depression of the Arch from Sitting to Standing.*—This variable was also computed in the manner described under variable 5. (The navicular heights were measured in the following order: sitting, standing, standing plus one-fourth body weight. They were all measured with the feet in the position described under variable 1.)

8. *Ankle Flexion.*—This measurement was made with a goniometer with its joint centered over the posterior tubercle of the inner malleolus, (behind and slightly superior to the inferior tip of the malleolus), the upper end of the goniometer centered over the greatest bulge of the medial condyle of the knee, and the lower arm centered over the medial surface of the head of the first metatarsal. The dorsal angle was read to the nearest degree while the subject actively dorsi-flexed the ankle to the maximum position which he could hold.

9. *Ankle Extension.*—This measurement was taken as for variable 8, with the dorsal angle read while the subject actively plantar flexed his foot as far as he could. The smaller the angle the greater the flexibility.

10. *Ankle Range.*—The score was the difference between the ankle flexion and ankle extension scores.

11. *Ankle Mid-point.*—The midpoint of the ankle range was computed.

12. *Trunk Flexibility.*—The height of the suprasternale (the notch between the medial ends of the clavicles) was measured with the subject sitting at maximum extension with the legs flexed to a right angle. The height of the suprasternale was also recorded while the subject sat with his knees fully extended and his trunk flexed forward as far as he could momentarily hold the position. Trunk flexibility was then expressed as the flexed score divided by the extended score, in order that the measurement not be a function of the sitting height of the individual. The smaller the score the greater the flexibility.

13. *Rotation Inward* (Figure 4).—This variable was the total inward rotation which the individual could actively maintain. It was measured as the angle of the mid-longitudinal axis of the foot with the individual's sagittal plane. The measurement was made with the subject sitting with his knees straight and his hands in his lap. A sandal with a plywood sole was strapped to the feet so that the edge of the sole corresponded to the mid-longitudinal axis of the foot. The individual rolled the feet and legs inward as far as possible. A blackboard grooved sagittally was then held vertically against the plywood soles and a chalk line drawn on the blackboard following the plywood edge and representing the mid-longitudinal axis of the foot. The angle with the sagittal plane was measured for each foot with a transparent projector, and recorded to the nearest degree.

14. *Rotation Outward* (Figure 5).—The measurement was similar to that for variable 13, except that the individual turned his feet and legs outward as

far as he could without bending his knees or twisting his pelvis.

15. *Rotation Range.*—The sum of the inward and outward rotation scores was used.

16. *Rotation Midpoint.*—The midpoint of the rotation range was computed. If this midpoint lay in the outward rotation range it was recorded as plus; if in the inward range, minus.

17. *Pronation.*—Using the same plywood soles and the same sitting position the individual pronated both feet as strongly as possible. The blackboard was brought horizontally up under the heel and a chalk line drawn using the plywood sole as a guide to the plane of the sole of the foot.

18. *Supination* (Figure 6).—As for variable 17.

19. *Supination-Pronation Range.*—As for variable 15.

20. *Supination-Pronation Midpoint.*—As for variable 16. If the midpoint lay in the supination range it was recorded as plus; if in the pronation range it was recorded as minus.

21. *Supinator Strength* (Figure 7).—The strength of the supinator muscles was measured as the pounds pull exerted when a band was placed around the foot just posterior to the first metatarso-phalangeal joint and attached to a spring balance. In each case care was taken that the adjustable band was at a right angle to the longitudinal axis of the foot, and the foot at a right angle to the lower leg and in a sagittal plane at the point of greatest effort. The subject sat with the knees bent to a right angle and no movement was permitted at the knee or hip. For convenience and ease of the examiner a frame was constructed to which the scale could be attached and adjusted. This apparatus was similar in principle to the one described by Osgood (14). The strongest of three pulls divided by the individual's body weight was the score used.

22. *Pronator Strength.*—As for variable 21.

23. *Supinator-Pronator Strength Balance.*—The difference between the supinator strength score and the pronator strength score was used. Positive scores indicate a balance in favor of the supinators.

24. *Toe Flexor Strength* (Figure 8).—The individual stood on a stool one inch lower than the platform of a bathroom type scale. He placed the toes of one foot evenly on the platform of the scale but kept the ball and heel on the stool. He then pressed with his toes on the scale as hard as he could without lifting his heel. The score used was the highest pressure momentarily divided by body weight.

25. *Cortical Thickening of the Second Metatarsal.*—This was measured according to the method described by Morton (13). Scores above 100 indicated ratios greater than 1:1.

26. *Length of the Second Metatarsal.*—This was also measured according to the method described by Morton (13). The scores were expressed in millimeters of projection of the second metatarsal beyond the first.

27. *Hypertrophy of the Second Metatarsal.*—Instead of following the method described by Morton, the measurements of the shafts of the metatarsals, as computed for variable 25, were used. The width of the shaft of the second metatarsal was divided by the sum of the widths of the shafts of the third, fourth, and fifth metatarsals divided by three. Scores above 100 indicate ratios greater than 1:1.

28. *Anterior Alignment of the Ankle* (Figure 9).—This and variables 29 and 30 were measured as the lateral or medial deviation of the landmark from the cleft of the skin at the base of the second and third metatarsals. The deviations were read by the use of a transparent screen vertically lined in half centimeter spaces. The individual stood on one side of the screen while the

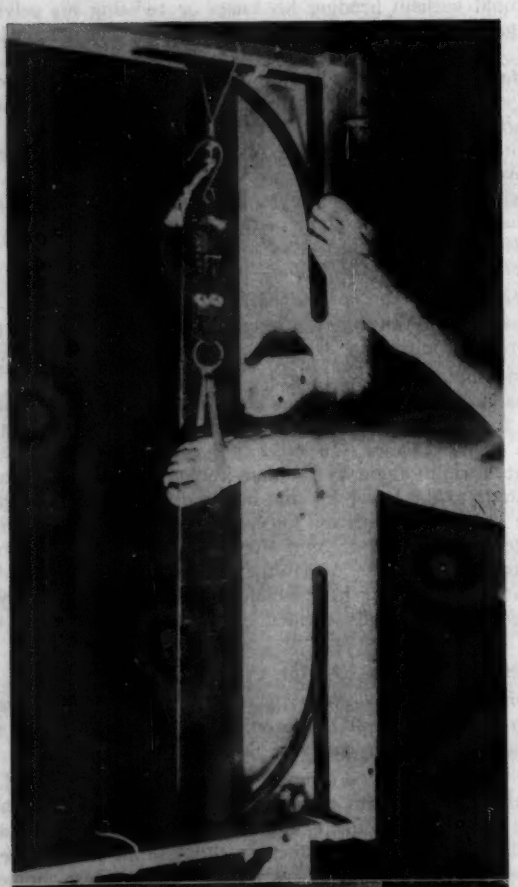

Fig. 7.

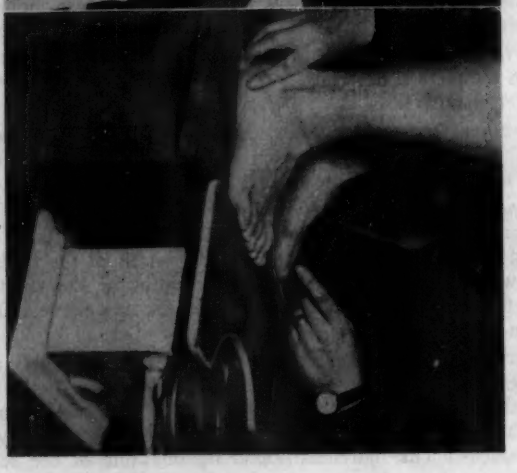

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

TABLE I (a)
SIGNIFICANCE OF DIFFERENCES BETWEEN NORMAL, PRONATED, PAINFUL FEET
("t" technique)

	Variable	Sex	Normal Mean	Normal S.D.	Pronated Mean	Pronated S.D.	Painful Mean	Painful S.D.	Significance of Differences: Normal-Pronated "t"	Normal-Pronated %	Pronated-Painful "t"	Pronated-Painful %	Normal-Painful "t"	Normal-Painful %
1	Morton's Angle	B	18.88	7.56	21.05	5.34	18.16	7.02	1.054	30	1.495	20	.137	90
		G	17.86	5.62	14.36	6.06	15.62	6.68	2.556	2	.744	50	1.461	20
2	Angle Foot-Ankle		81.72	3.182	82.18	3.656	81.02	2.818	.743	50	1.781	10	1.264	30
3	Ankle Overhang		1.69	.320	2.335	.591	1.981	.509	8.086	.1	3.278	1	3.863	.1
4	Navic. Overhang		.701	.051	.747	.052	.735	.055	4.752	.1	1.088	30	3.479	.1
5	Arch Sit-Stand + ¼		19.5	5.901	21.41	9.285	21.999	7.554	1.4151	20	.343	80	.6518	60
6	Arch. Stand-Stand + ¼		5.568	4.070	5.154	4.550	4.56	3.804	.537	60	.709	50	1.368	20
7	Arch. Sit-Stand		14.229	6.144	15.981	8.874	17.472	7.692	1.315	20	.899	40	2.598	2
8	Ankle Flexion		82.131	4.077	84.481	5.599	82.838	4.577	1.903	10	1.626	20	.9012	40
9	Ankle Extension		18.24	5.624	16.692	5.250	15.36	6.366	1.327	20	1.145	30	2.696	1
10	Ankle Range		63.25	6.638	68.095	6.89	67.583	7.155	3.926	.1	.3637	80	3.442	.1
11	Ankle Midpoint		49.930	3.482	49.693	3.948	48.749	3.915	.352	80	1.205	30	1.850	10
12	Trunk Flexibility		70.774	7.884	66.924	6.908	69.138	7.516	2.886	1	1.672	20	1.155	30
13	Rotation In	B	46.452	10.104	50.499	7.464	49.32	8.988	1.449	20	.429	70	1.091	30
		G	50.859	9.225	53.727	10.158	53.52	7.476	1.663	10	.085	90	1.274	30

	Variable	Sex	Normal Mean	Normal S.D.	Pronated Mean	Pronated S.D.	Painful Mean	Painful S.D.	Significance of Differences: Normal-Pronated "t"	Normal-Pronated %	Pronated-Painful "t"	Pronated-Painful %	Normal-Painful "t"	Normal-Painful %
14	Rotation Out	B	60.646	7.932	63.264	7.628	61.916	6.096	1.137	30	.630	60	.807	40
		G	66.000	6.834	64.424	6.990	66.24	7.470	.969	40	.925	40	.139	90
15	Rotation Range		113.136	12.700	115.92	13.032	114.40	13.052	1.200	30	.584	60	.528	60
16	Rotation Midpoint		7.467	5.841	6.453	5.187	7.567	4.641	1.008	40	1.119	30	.997	40
17	Pronation	B	18.388	5.754	20.948	7.744	18.32	7.238	1.307	20	1.129	30	.039	100
		G	23.12	5.214	22.122	5.926	22.622	4.570	.766	50	.543	60	.396	70
18	Supination		31.20	7.192	34.116	7.548	33.33	6.270	2.167	5	.5663	60	1.704	10
19	Pro-Sup Range	B	47.322	9.57	54.315	10.569	49.32	10.131	2.361	5	1.552	20	.744	50
		G	55.326	9.951	57.00	10.020	57.345	8.334	.712	50	.140	90	.852	40
20	Pro-Sup Midpoint		5.451	3.57	6.782	4.737	6.427	4.146	1.778	10	.399	70	1.399	20
21	Supination Strength		29.764	5.145	30.625	4.805	32.014	5.435	.954	40	1.36	20	2.208	5
22	Pronation Strength	B	24.720	4.781	26.576	4.254	24.23	4.236	1.367	20	1.669	10	.397	80
		G	24.075	4.877	25.932	4.83	26.788	5.193	1.635	10	.645	60	2.163	5
23	Sup-Pro Str. Balance		5.557	4.254	4.213	4.965	6.099	4.295	1.488	20	1.825	10	.693	50
24	Toe Flexor Strength		70.75	10.998	68.538	10.658	68.118	10.449	1.113	30	.200	90	1.337	20
25	Cortical Thickening		137.43	17.225	139.17	20.005	138.40	16.070	.5019	60	.208	90	.312	80
26	Length MII-MI	B	2.5	2.85	2.05	2.228	3.07	2.708	.554	60	1.254	30	.57	60
		G	.69	2.579	2.30	2.519	1.04	2.75	2.667	1	1.924	20	.523	60

	Variable	Sex	Normal Mean	Normal S.D.	Pronated Mean	Pronated S.D.	Painful Mean	Painful S.D.	Significance of Differences: Normal-Pronated "t"	Normal-Pronated %	Pronated-Painful "t"	Pronated-Painful %	Normal-Painful "t"	Normal-Painful %
27	Hypertrophy MII		107.87	8.975	112.22	9.663	111.01	8.723	2.526	2	.651	60	1.933	20
28	Ant. Align. Ankle	B	M1.7	.935	M2.19	.773	M1.80	.645	1.584	20	1.757	20	.072	100
		G	M1.4	.493	M1.39	.555	M1.45	.661	.121	100	.403	70	.353	80
29	Ant. Align. Patella		M2.07	.902	M2.27	1.173	M2.07	.973	.147	90	.907	40	.029	100
30	Ant. Align. Sup. Spine	B	L .15	1.801	M .28	1.562	L .18	1.41	.814	50	1.075	30	.057	100
		G	L1.37	1.471	L1.33	1.494	L1.16	1.466	.111	100	.396	70	.538	60
31	Post. Align. Tendon		M .09	.241	M .28	.238	M .25	.218	4.332	.1	.703	50	3.757	.1
32	Post. Align. Knee		L .72	.951	L .61	.984	L .37	.971	.614	60	.474	70	1.392	20

TABLE I (b)

CHI SQUARE AND DIFFERENCES BETWEEN PROPORTIONS (P*), TECHNIQUES, AND PERCENT LEVELS OF CONFIDENCE

		Normal-Pronated X^2	Normal-Pronated %	Normal-Pronated P	Normal-Pronated %**	Pronated-Painful X^2	Pronated-Painful %	Pronated-Painful P	Pronated-Painful %**	Normal-Painful X^2	Normal-Painful %	Normal-Painful P	Normal-Painful %**
33	Pain on Press MI-MII	1.732	20	1.303	10	27.67	1	6.39	.1	21.37	1	5.77	.1
34	Pain on Press. Tib	1.556	30	1.34	10	13.53	1	4.70	.1	12.17	1	5.54	.1
35	Pain on Press-Cal.	2.015	20	1.78	4	16.40	1	5.18	.1	11.84	1	3.52	.1

* $P = \frac{P_1 - P_2}{\sqrt{\frac{P_1 Q_1}{N_1} + \frac{P_2 Q_2}{N_2}}}$

** H. E. Garrett. *Statistics in Psychology and Education*. New York: Longmans, Green & Co. 1932, p. 134.

examiner looked through the screen. Measurements were read as the individual stood in the position of natural stance after ten steps of walking in place, and were recorded to the nearest half space. The score used was an average of three trials, and was later expressed in quarter centimeters of medial or lateral deviation.* The landmark for the ankle was the middle of the anterior aspect of the ankle as measured with calipers with the blades held parallel with the longitudinal axis of the foot.

29. *Anterior Alignment of the Patella.*—As for variable 28. The center of the patella was the landmark used.

30. *Anterior Alignment of the Anterior Superior Spine.*—As for variable 28. A woven strap belt was adjusted around the hips at this level and thumb tacks lightly stuck in the belt over the medial edge of the anterior superior spines.

31. *Posterior Alignment of the Achilles Tendon* (Figure 10).—This and variable 32 were measured using the same screen techniques described for the anterior landmarks, but with deviations measured from the center of the contact area of the heel with the table. The center of the Achilles tendon was marked at the level of the inner malleolus.

32. *Posterior Alignment of the Knee.*—As for variable 31. The landmark was located by bisecting the knee with the caliper blades held in a sagittal plane.

33. *Pain on Pressure Under the Junction of the First and Secand Metatarsals with the First Cuneiform* (Figure 11).—This and variables 34 and 35 were measured by having the subject lower the weight of the leg and foot onto a half inch diameter padded nailhead which was resting on the platform of a bathroom type scale. The minimum pounds pressure required to enlist a pain response was the score used. If no pain was recorded at twelve pounds, the pressure was automatically discontinued.

34. *Pain on Pressure Under the Insertion of the Tibialis Anterior.*—As for variable 33.

35. *Pain on Pressure Under the Posterior Insertion of the Plantar-calcaneo-navicular Ligament into the Calcaneus.*—As for variable 33.

Reliability of Measurements.—Coefficients of correlation by the Pearson Product Moment method, based on measurements obtained on two different days ranged from .687 to .964 with an average coefficient of .786.

RESULTS

Sex Differences

Means, standard deviations, and "t" significances of differences were computed for the boys' and girls' data in each of the three groups, normal, pronated and painful. Variables 1, 13, 14, 17, 19, 22, 26, 28, and 30 show sex differences significant at the two percent level of confidence (Table Ia). These differences may be related in part at least to the wider pelvic width among girls. They also suggest a characteristic greater flexibility among girls and a narrower angle of out-toeing among girls.

A Description of the Normal Foot

A description of the normal or well aligned foot based on averages of the various measurements (Table Ia Normal) included several factors of interest. There was a nineteen-degree angle be-

*To eliminate the medial-lateral distribution of scores around a zero midpoint in correlation techniques a constant (10) was added to each score.

TABLE II

INTERCORRELATIONS OF VARIABLES GIVING SIGNIFICANT DIFFERENCES IN MEANS AMONG NORMAL, PRONATED, AND PAINFUL GROUPS (PEARSON PRODUCT MOMENT METHOD)

Variable	1. Morton's Angle	3. Ankle Overhang	4. Navicular Overhang	7. Arch Depress.—Sit to Stand	9. Ankle Extension (lowest score = greatest flexibility)	10. Ankle Range	12. Trunk Flexibility (lowest score = greatest flexibility)	21. Strength Supinators*	26. Length Second Met.	27. Hypertrophy Second Met.	31. Posterior Align. Tendon	33. Pain on Pressure MI-II
1	.....	—.3101	—.1368	—.3011	—.1417	.0357	.1940	—.1469	—.0625	.0012	—.3744	.....
3	.....	.....	.6577	.1914	—.1548	.1540	—.0759	.0417	.0251	.1644	.5849	.....
4	.....	.....	.....	.2100	—.1597	.1364	—.1220	—.0403	—.0829	.0729	.4322	.....
7	.....	.....	.....	.....	—.0024	.1394	—.2596	.0573	.1098	.0539	.1250	.20**
9	.....	.....	.....	.....	.....	—.6846	—.0144	—.1387	—.0762	—.0605	—.0994	.....
10	.....	.....	.....	.....	.....	.....	—.1788	.2240	.0469	.1024	.1751	.12**
12	.....	.....	.....	.....	.....	.....	.....	—.1027	—.0002	.0105	—.0800	.....
21*	.....	.....	.....	.....	.....	.....	.....	.....	.0308	.0650	.0269	—.05**
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.0895	.0985	.....
27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.0144	.....
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* Differences significant at the 5% level of confidence only. All others at 2% level or less.
** Tetrachoric correlations used with dichotomous data.

TABLE III

TRISERIAL AND BISERIAL CORRELATIONS

		A		B		C	
		Normal-Pronated-Pain	Normal-Pain-Pronated	Normal-Pronated*		No Pain-Pain**	
Variable		*Triserial*	*Triserial*	*Biserial*		*Biserial*	
1	Morton's Angle	.....	—.2718	—.401	....	.0483	....
3	Ankle Overhang	.....	.5541	.665	....	.0303	....
4	Navicular Overhang	.....	.3964	.511	....	.0738	....
7	Arch Depression Sit to Stand	.2181	.....	.218	....	.0151	....
9	Ankle Extension	—.2617	.....	—.102	....	—.2298	....
10	Ankle Range	.3161	.....	.292	....	.2021	....
12	Trunk Flexibility	—.1216	.....	—.229	....	—.0040	....
21	Strength Supinators	.2002	.....	.094	....	.2194	....
26	Length Metatarsal II	.....	.2801	.049	....	—.0902	....
27	Hypertrophy MII	.1838	.2314	.268	....	.0918	....
31	Posterior Alignment-Tendon.	.3094	.4320	.440	....	.1239	....
				*Biserial***	*Tetrachoric*	*Biserial***	*Tetrachoric*
33	Pain on Pressure MI-II	.....	.....	.012	—.05	.4081	.66
34	Pain on Pressure Tib Ant	.....	.....	.062	.16	.2873	.55
35	Pain on Pressure Cal	.....	.....	.223	—.10	.0880	.56

* This is a composite of the normal group plus the normally aligned painful feet correlated with the pronated group plus the pronatedly aligned painful feet.

** The normal and pronated groups are combined into a non-painful group which is correlated with the painful group.

*** Based on the data of only those subjects who reported pain on pressure.

tween the two feet in standing. The ratio of overhang of the inner malleolus to that of the outer malleolus from the mid-longitudinal axis of the foot was 1.7:1.0, indicating that even in feet judged to be well aligned, the body weight fell somewhat more medialward than directly over the base of support. In standing the ankle and patella fell one to two centimeters medialward of the cleft between the second and third toes. Outward rotation of the lower extremity was greater than inward rotation, with the midpoint being one of seven degrees of outward rotation. Supination was greater than pronation with a midpoint of six degrees of supination. Supinator muscle strength was thirty percent of body weight and pronator strength twenty-four percent. Thus the supinators were slightly stronger than the pronators. The toe flexor muscle strength averaged seventy per cent of body weight. X-ray studies showed the second metatarsal to be longer than the first metatarsal in sixty-six percent of the cases with a two millimeter average greater length. Very slight hypertrophy and cortical thickening of the second metatarsal was also average for the well aligned or normal group.

Statistically Significant Differences Between Normal, Pronated and Painful Groups

(Two percent level of confidence or better)

Means, standard deviations, and "t" significances of differences were computed for the normal, pronated and painful groups. Boys' and girls' scores were combined except where significant differences were found (Tables Ia and Ib). Both the painful and the pronated groups differ from the normal group by showing greater ankle overhang (variable 3), greater medial displacement of the navicular (variable 4), greater medial displacement of the tendon of Achilles (variable 31) and greater flexibility range of the ankle (variable 10). The pronated group was further differentiated from the normal group by showing greater flexibility of the trunk and hamstrings (variable 12), greater length and hypertrophy of the second metatarsal (variables 26 and 27), and less out-toeing among the girls (variable 1). The painful group was further differentiated from the normal group by showing greater extension at the ankle (variable 9), greater depression of the arch on weight bearing (variable 7), and greater pain to pressure on the sole of the foot (variables 33, 34, 35).

The painful group was significantly different from the pronated group only in the greater pain to pressure on the sole of the foot (variables 33, 34, 35) and lesser ankle overhang (variable 3).

Interrelations of Variables

1. *Pronation.*—Ankle overhang (variable 3), navicular overhang (variable 4), and medial displacement of the Achilles tendon (variable 31) are frequently mentioned as criteria of pronation and

weak feet. In this study they are biserially correlated with the subjective criterion of pronation, the coefficients being .665, .511, and .440 respectively. They show intercorrelation coefficients ranging from .658 to .432.

2. *Angle of stance.*—In this study the angle of toeing out (variable 1), which has also been stressed in the literature as a criterion of weak feet, showed a negative biserial correlation of —.401 with the subjective criterion of pronation, and intercorrelations of —.301, —.137 and —.374 with variables 3, 4, and 31, which may be considered partial criteria of pronation. These data together with a mean out-toeing angle of eighteen degrees between the two feet among the normal cases therefore challenge the concept of the out-toeing foot as a pronated and weak foot.

3. *Angle of the lower extremity as a whole.*—The vertical alignment of the anterior part of the foot, the center of the ankle, the patella, and the anterior-superior spine is a criterion of foot mechanics frequently mentioned in the literature (6, 8, 10, 11, 15, 16). This alignment assumes a parallel foot position. Since the cases in this study showed a mean out-toeing angle of fourteen to twenty degrees, it is only natural that the alignment of the ankle, patella, and anterior-superior spines (variables 28, 29, and 30) over the center of the anterior part of the foot should depart from this vertical relationship. This is shown by the medial displacement average scores for variables 28 and 29 (Table I). Although the anterior-superior spine is a conveniently palpable landmark, it generally lies somewhat lateralward to the mechanical center of the hip joint. For this reason its validity in a vertical alignment criterion may be questioned. The alignment data of this study unfortunately have not been corrected for length of leg. For this reason their significance is limited. However inspection of the data for variables 28, 29, and 30 (Table I) shows the center of the ankle and the center of the patella to be quite well aligned vertically, even though they both were medially displaced from the center of the forepart of the foot. If a moderate amount of out-toeing may be considered normal, medial displacement of the ankle and patella from a vertical above the fore part of the foot should not be regarded as abnormal.

4. *Flexibility.*—In this study flexibility of the arch, ankle, and trunk (variables 7, 10, and 12) showed low but statistically significant biserial correlation coefficients with the subjective criterion of pronation indicating greater flexibility associated with pronated feet, the coefficients being .218, .292, and .229 respectively. The intercorrelations between these variables were low and barely significant. Increased flexibility and arch depression on weight bearing have been cited in the literature as signs of weak feet (1, 4, 7, 8). In this study greater arch depression (variable 7) was negatively correlated with

out-toeing (variable 1), indicating the greater arch stability associated with out-toeing rather than with the more parallel foot position.

Thirteen of the fourteen flexibility variables, including arch, ankle, hip, and trunk ranges, showed greater flexibility among the pronated and painful groups in distinction from the normal group. Although these differences were not all statistically significant at the two percent level of confidence the fact that the greater flexibilities all lay in the same direction suggests the possibility of a common flexibility factor. Dr. Arthur Steindler, in personal communication with the writer, has commented on the prevalence of pronation among people with general joint looseness. This problem might well be investigated further.

Outward rotation (variable 14) was greater than inward rotation in all three groups in this study. The midpoint of the range was therefore one of slight out-toeing. Without implying a causal relation, this finding harmonizes with the slight out-toeing which was also characteristic of all groups.

Supination (variable 18) was greater than pronation (variable 17) in all three groups of this study, with the midpoint therefore being one of slight supination. The pronated group showed a midpoint in even greater supination than the normal group. It has been observed that the normal foot supination of the infant if abnormally prolonged into early years of walking may be a cause of pronation as the child attempts to bring the sole of the foot into the horizontal plane which is essential in weight bearing. It is possible that this foot supination may persist throughout childhood and be a factor in foot disability. The data of this study were not conclusive on this point, but suggest the desirability of further study of the relation of degree of habitual pronation to the midpoint of the pronation-supination range.

5. *Strength.*—It has been recorded in the literature that the supinators become progressively weaker as the foot disalignment and disability increase (14, p. 303); and conversely that there is little or no variation in the supinator-pronator strength ratio among feet with no pronation and among feet with first- and second-degree pronation, the supinators being the stronger in all cases (13, p. 198).

The data of this study showed no differences significant at the two percent level of confidence between normal, pronated, and painful feet as regards supinator, pronator, or toe flexor strength proportional to body weight (variables 21, 22, 23, and 24). The data of this study did not show pronated and painful feet to be muscularly weak feet. The data question the value of routine use of foot strengthening exercises in the treatment of pronation. Perhaps a test of muscle strength is justified as one basis for determining the type of treatment for disaligned feet. The low positive correlation of

.224 between supinator strength and ankle range was also interesting, since ankle range was also slightly correlated with pronation as measured by ankle overhang (variable 3).

6. *Morphology.*—The importance of a shorter and hypermobile first metatarsal in the decompensated foot was first stressed by Morton (13), and since then by numerous orthopedists (3, 7, 9). The theory advanced by Morton is that the shorter and dorsally hypermobile first metatarsal does not support the medial border of the foot in good alignment, but permits it to roll into pronation before the ligaments become taut. The second metatarsal therefore carries more than its normal share of body weight, and as a result shows hypertrophy of its shaft and thickening of the cortex of the shaft. In order to determine the relation of these factors in the feet of this study, x-rays were taken of the forepart of both feet.

Some degree of shortness of the first metatarsal was found in seventy percent of the entire group, with girls of the pronated group only showing a statistically greater shortening over the girls of the normal group. This factor did not differentiate the normal from the painful group.

Very slight hypertrophy of the second metatarsal was also characteristic of all groups with the pronated group showing a significantly greater hypertrophy than the normal group. A low positive correlation of .164 between hypertrophy and pronation, as measured by ankle overhang (variable 3) was found. This factor did not differentiate the normal and the painful groups. Slight cortical thickening of the second metatarsal (variable 25) was also characteristic of all groups, but did not differentiate the groups. No data were available on hypermobility of the first metatarsal, since no objective method of measurement was available.

It must be recognized that relative hypertrophy and cortical thickening are adaptive sequellae of long continued relative stresses on the various metatarsals. As such they would hardly be expected to have reached a maximum in children of ages eight to fourteen. Further study on this aspect of the problem is indicated. A study of metatarsus primus varus might also be profitable.

7. *Pain on pressure.*—Areas of tenderness to pressure on the sole of the foot have long been recognized as signs of foot strain (5, 17). Three measurements of this type (variables 33, 34, and 35) were included in this study in an effort to determine their relation to normal, pronated, and painful feet. All three variables when subjected to the Chi-Square technique show differences significant at the one percent or less level of confidence between the normal and painful groups and between the pronated and painful groups. These variables do not differentiate the normal and pronated groups satisfactorily. Inspection of the biserial correlations of these variables

with the (1) normal-pronated and (2) normal-painful dichotomies, and inspection of the triserial correlations of (1) normal-pronated-painful and (2) normal-painful-pronated orders (Table III) shows pain to pressure on the sole of the foot to be more related to painful function than to pronated alignment of the feet. A low positive correlation of pain on pressure (variable 33) with depression of the arch (variable 7) of .20 (Table II) is also interesting in this connection, and reenforces the possibility that flexibility of the arch is a factor in pathology.

It is possible that further study of these pain on pressure variables, using a technique which would afford a continuous distribution of scores, rather than the twelve-pound ceiling of the present study, would contribute data with significant diagnostic value.

Multiple Correlations

Using the most promising triserial, biserial, and tetrachoric correlation coefficients from Tables II and III, the following multiple correlation coefficients were computed with both the criterion of pain and the criterion of pronation (Table IV).

TABLE IV
MULTIPLE CORRELATIONS

Pain		Pronation	
Triserial		*Triserial*	
$R_{o.79(10)(12)(21)}$	= .4048	$R_{o.34(37)(21)}$	= .5913
$R_{o.7(10)(21)}$	= .3789	$R_{o.34(37)}$	= .5741
Triserial and Tetrachoric		*Biserial*	
		$R_{o.134(21)}$	= .7117
$R_{o.7(10)(21)(33)}$	= .7260	$R_{o.134}$	= .7056
$R_{o.(10)(21)(33)}$	= .7099	$R_{o.13}$	= .7053
$R_{o.7(10)(33)}$	= .6956		
$R_{o.(10)(33)}$	= .6953		
Tetrachoric			
$R_{o.(33)(34)(37)}$	= .6736		
$R_{o.(33)(37)}$	= .6610		

For the criterion of pain, the multiple correlation coefficient based on the four variables of depression of the arch from sitting to standing, flexibility of the ankle, strength of the supinator muscles, and pain on pressure (variables 7, 10, 21, and 33) was .7260. However, pain on pressure alone gave a tetrachoric correlation coefficient of .66 with the criterion of pain.

For the criterion of pronation, the multiple correlation based on the four variables of angle of stance, medial deviation of the ankle from the mid-longitudinal axis of the foot, medial prominence of the navicular, and medial deflection of the Achilles tendon (variables 1, 3, 4, 31) was .7117. However, the two variables of angle of stance and medial deviation of the ankle from the mid-longitudinal axis of the foot gave a multiple correlation coefficient of .7053.

TABLE V

MULTIPLE FACTOR ANALYSIS—ORIGINAL UNROTATED LOADINGS

	Factors					
Variables	*I*	*II*	*III*	*IV*	*V*	Σx^2
1. Out-toeing Angle	.3894	.0294	.5335	.1163	..0768	.4565
3. Ankle Overhang	.6826	.5060	.0152	.0552	.1427	.7455
4. Navicular Overhang	.5569	.5114	.1188	.3162	.0991	.6955
7. Arch Depression—sit to stand	.3961	.1538	.2345	.1973	.1716	.3038
9. Ankle Extension	.4309	.2810	.6360	.1023	.1630	.7063
10. Ankle Range	.5634	.4053	.4363	.0177	.1766	.7036
12. Trunk Flexibility	.2823	.2156	.1938	.2537	.1287	.2448
21. Strength Supinators	.2302	.2661	.0202	.2275	.1476	.1978
26. Length Second Metatarsal	.1281	.0841	.0879	.1534	.0887	.0626
27. Hypertrophy Second Metatarsal	.1755	.0470	.0974	.1632	.1715	.0985
31. Post. Align. Tendon	.5871	.3197	.1785	.0670	.2715	.5570

TABLE VI

MULTIPLE FACTOR ANALYSIS—FINAL ROTATED LOADINGS

Variables	*Factor I*
3. Ankle Overhang	.8420
31. Post. Align. Tendon	.6622
7. Arch Depression-sit to stand	.2281
27. Hypertrophy Second Metatarsal	.1508
10. Ankle Range	.1180
12. Trunk Flexibility	.0995
4. Navicular Overhang	.1870
9. Ankle Extension	.0786
26. Length Second Metatarsal	.0447
21. Strength Supinators	.0023
1. Out-toeing Angle	—.3600

Variables	*Factor II*
9. Ankle Extension	.8343
10. Ankle Range	.7919
4. Navicular Overhang	.4927
21. Strength Supinators	.1809
27. Hypertrophy Second Metatarsal	.1034
3. Ankle Overhang	.0806
31. Post. Align. Tendon	.0782
26. Length Second Metatarsal	.0642
12. Trunk Flexibility	.0138
7. Arch Depression-sit to stand	.0037
1. Out-toeing Angle	—,2420

Variables	*Factor III*
4. Navicular Overhang	.6417
7. Arch Depression-sit to stand	.4914
12. Trunk Flexibility	.4752
1. Out-toeing Angle	.3831
10. Ankle Range	.2447
21. Strength Supinators	.2015
31. Post. Align. Tendon	.0867
26. Length Second Metatarsal	.0748
3. Angle Overhang	—.0134
9. Angle Extension	—.0213
27. Hypertrophy Second Metatarsal	—.0407

Variables	*Factor IV*
1. Out-toeing Angle	.3387
21. Strength Supinators	.3233
26. Length Second Metatarsal	.1979
27. Hypertrophy Second Metatarsal	.1555
31. Post. Align. Tendon	.1260
3. Ankle Overhang	.0730
10. Ankle Range	.0511
9. Ankle Extension	.0182
7. Arch Depression-sit to stand	.0119
12. Trunk Flexibility	—.0628
4. Navicular Overhang	—.1070

Variables	*Factor V*
31. Poterior Align. Tendon	.2981
26. Length Second Metatarsal	.1070
10. Ankle Range	.0144
9. Ankle Extension	—.0569
12. Trunk Flexibility	—.0700
1. Out-toeing Angle	—.0833

Variables	*Factor V*
7. Arch Depression—sit to stand	—.1009
21. Strength Supinators	—.1410
4. Navicular Overhang	—.1481
3. Ankle Overhang	—.1579
27. Hypertrophy Second Metatarsal	—.1980

Multiple Factor Analysis*

Using the Pearson Product Moment correlation coefficients from Table II, and Thurstone's simplified multiple factor method,** unrotated loadings for the first five factors were computed (Table V). The rotated loadings or zero-order correlations of each variable with each of the five factors are presented in order of size in Table VI.

Factor I appears to be related to the disalignment of the foot and ankle, primarily as concerns degree of pronation. Medial overhang of the ankle (variable 3) had a loading of .8420 and medial deflection of the Achilles tendon a loading of .6622, while the out-toeing angle of stance (variable 1) had a negative loading of —.3600.

Factor II appears to be primarily an ankle flexibility factor inasmuch as ankle extension (variable 9) had a loading of .8343 and ankle range a loading of .7919. It should be pointed out that ankle range is composed of the difference between ankle extension and ankle flexion, and so is obviously related to ankle extension.

Factor III appears to be a general flexibility factor rather than a flexibility factor specific to the foot. It is prominent in medial displacement of the navicular (variable 4) with a loading of .6417, in depression of the arch (variable 7) with a loading of .4914, and also in trunk and hamstring flexibility with a loading of .4752.

Factor IV may be tentatively identified as strength of the foot, although it appears to be of little significance. If there had been more variables with strong strength components in this analysis the strength factor might have shown up more clearly.

Factor V shows no loadings in this analysis high enough to make an attempt to identify the factor, and is probably simply a residual factor. It would be highly desirable to continue the factor analysis approach to the study of the feet, utilizing a larger number of variables, in order to bring out all of the significant factors that may be related to the structure and function of the foot.

SUMMARY

This study has presented mean scores and significant differences for groups of normal, pronated, and painful feet with regard to thirty-five anthropometric and x-ray variables related to statics, flexibility, strength, morphology, and sensitivity to pain. These data included several significant and in some cases challenging concepts.

1. Out-toeing angles of fourteen to twenty degrees between the two feet were characteristic of normal, pronated, and painful feet, with the girls of the pronated groups showing less out-toeing than the normal group.

*The factor analysis was carried out under the direction of Dr. C. H. McCloy, Department of Physical Education, State University of Iowa.

**L. L. Thurstone. *Vectors of Mind.* Chicago: University of Chicago Press, 1935.

2. Out-toeing was negatively correlated with three criteria of pronation.

3. Both pronated and painful groups showed greater flexibility than the normal group with regard to the arch, the ankle, and the trunk and hamstrings, and similar but less significant greater flexibility in ten of eleven additional flexibility variables studied.

4. Low positive significant correlations were found between flexibility of the arch and criteria of pronation, and low negative correlations between flexibility of the arch and degree of out-toeing.

5. The pronated and painful groups showed as great strength of pronator, supinator, and toe flexor muscles proportional to body weight as the normal group. In this study the pronated and painful feet were not muscularly weak feet.

6. The condition of short first metatarsal was frequent in the normal, pronated, and painful groups, with the incidence only slightly higher in the two latter groups.

7. Pain on pressure to the sole of the foot differentiated the normal from the painful feet, and the pronated from the painful feet. It should be studied further as a possible diagnostic criterion of potentially painful feet.

8. The sex differences shown seem to be related to the greater pelvic width of girls, and suggest the possibility of greater flexibility among girls.

9. Multiple factor analysis indicates the presence of three or four common factors in foot structure and function. Three have been tentatively identified as foot disalignment, ankle flexibility, and general flexibility. A possible fourth factor may be related to strength of the feet.

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Research Abstracts

PREPARED FOR THE
NATIONAL COUNCIL OF THE RESEARCH SECTION

By Granville B. Johnson

Anatomy

Krahl, Vernon E., "The Torsion of the Humerus: Its Localization, Cause, and Duration in Man," *American Journal of Anatomy,* 80:3, pp. 275-319 (May, 1947).

Evidence is presented which renders a concept of a twisted humeral shaft untenable. The illusion of a twisted diaphysis is created by the response of the bone to pressure and tension stresses. Humeral torsion occurs at the proximal epiphyseal cartilage, a zone of relative weakness and active growth. The cone and cap arrangement at the epiphyseal union resists shearing forces but permits slight rotational movements of the epiphysis in the fetus and infant. Cone growth parallels increase in muscle strength and reaches its maximum between the ages of 10 and 12. The contractions of the humeral rotators, which set up torsional stresses across the epiphyseal plate are primarily responsible for the production of humeral torsion. Large torsion angles are associated with powerful muscles, while weaker subjects have small torsion angles. The physiological cross-sectional area of a muscle which determines its strength may be obtained by means of a simple but accurate photographic technique. Torsion begins in the fetal humerus in the twentieth week and ceases abruptly at maturity. Primary or inherited torsion amounts to about 42°. To this is added a secondary or ontogenetic torsion of some 32°.—*Wistar Institute.*

Krahl, Vernon E., "A Comparison of Physiological Cross-Sectional Areas of Shoulder Muscles from Opposite Sides of the Body," *Anat. Rec.,* 99:1, pp. 127-132 (September, 1947).

The physiological cross-sectional areas of the pectoralis major, teres major, and latissimus dorsi muscles were measured in 42 cadavers. In 23 of these subjects the supraspinatus, infraspinatus, teres minor, and subscapulari were measured as well. The combined cross-sectional area was greater on the right side in 67 percent of cases, a situation apparently associated with handedness. When the left side predominated, the real and percentage differences between the combined cross-sectional area of the 2 sides was less than when the right side predominated. When cross-sectional areas were compared without regard to age or condition of the subject at death there was a side predominance of 12.7% in the "right-handed" and of 8.5% in "left-handed" cadavers. When the aged and diseased subjects are considered separately they show smaller area values than those in the younger group. However, the averages of both real and percentage differences of the 2 sides in victims of wasting diseases agree well with similar values in the younger subjects. On the other hand, these differences are distinctly lower in subjects of 65 years and over. In the latter group there is less difference (in cm^2) between the sides, and on the average, the percentage difference is roughly one-half that of the younger and diseased groups.—*Wistar Institute.*

Nutrition

Goyco, Jose A., Conrado F. Asenjo., "The Net Protein Value of Food Yeast," *Journal of Nutrition,* 33:5, pp. 593, 600 (May, 1947).

Using the nitrogen balance method of Mitchell and Carmon (1926) the protein values of 2 samples of food yeast (Torula utillis) and of one sample of brewers' yeast (Fleischmann type 2019) were determined. The Torula yeast

labeled no. 1084 was produced in England while the one labeled no. 3 was prepared in Puerto Rico. The results obtained were the following:

	Coefficient of true digestibility	*Biological value*	*Net protein value*
Torula yeast no. 1084	88.3	48.8	21.2
Torula yeast no. 3	87.3	45.3	20.0
Brewers' yeast	85.5	69.3	30.1

The 2 Torula yeasts have practically equal nutritive coefficients. The superior net protein value of the brewers' yeast over that of the Torula samples is due exclusively to its higher biological value since the protein (N x 6.25) content and digestible coefficients of the 3 yeast samples are practically the same. —*Wistar Institute.*

Storvick, Clara A., Margaret L. Fincke, Jeanne P. Quinn, Bessie L. Davey, "A Study of Ascorbic Acid Metabolism of Adolescent Children," *Journal of Nutrition,* 33:5, pp. 529-539 (May, 1947).

Three levels of intake were studied for 1 week each to determine ascorbic acid requirements of 4 girls and 4 boys aged 12 to 14 years. Foods were analyzed daily for reduced ascorbic acid using the method of Loeffler and Ponting (*Ind. Eng. Chem. Anal. Ed.,* 14: 846, 1942) and fasting plasma ascorbic acid values were determined daily by the micro-method of Farmer and Abt (*Proc. Soc. Exp. Biol. Med.,* 34: 146, 1936). The usual diet, tested the first week, contained a mean of 44 mg of ascorbic acid per day for the girls, and 61 mg for the boys. The girls maintained a mean plasma value of 0.34 and the boys 0.75 mg % during this week. The daily allowances of ascorbic acid recommended by the National Research Council (Reprint and Circular Series, no. 122, p. 2, 1945) resulted in mean plasma values of about 0.9 mg % for all subjects. Peak values during saturation ranged from 1.06 to 1.35 for 7 subjects and 1.37 mg % was reached by the eighth before the onset of a fever which persisted 1 day. A survey of 43 boys and 38 girls between the ages of 11 and 18 years revealed a mean plasma ascorbic avid value of 0.56 mg % which is considered lower than adequate (Report of Committee on Vitamins of Am. Acad. Pediat., Butler, 1940, p. 14).—*Wistar Institute.*

Hauck, Hazel M., "Plasma Levels and Urinary Excretion of Ascorbic Women During the Menstrual Cycle," *Journal of Nutrition,* 33:5, pp. 511-515 (May, 1947).

In 10 women subjects ascorbic acid metabolism was studied for a total of 23 periods of from 4 to 6 weeks' duration, during which 30 menstrual periods occurred. No evidence was found of unusual variability in either urinary excretion of ascorbic acid or fasting plasma ascorbic acid values associated with the menstrual cycle.—*Wistar Institute.*

Callison, Elizabeth C., Elsa R. Orent-Keiles, "Availability of Carotene from Carrots and Further Observations on Human Requirements for Vitamin A and Carotene," *Journal of Nutrition,* 34:2, pp. 153-165 (August, 1947).

Four human subjects, depleted of vitamin A liver stores as measured by impaired dark adaption, were given quick-frozen carrots, either cooked or uncooked, as provitamin A supplements and the amount necessary to restore normal vision determined. Carotene content and vitamin A value of the carrots were measured by chemical and bioassay procedures, respectively. The vitamin A value of the carrots measured by bioassay was 50.5 I.U. per carotene content of the vegetable. Accordingly the requirements of the human subjects range from 85 to 115 I.U. per kilo per day or from 30 to 40 I.U. per kilo per day, depending upon which vitamin A value for the carrots is used. These findings are compared with results from similar experiments in which the source of

vitamin A was crystalline carotene, U.S.P. reference cod liver oil no. 1, frozen peas or frozen spinach. It is probable that the human requirements indicated by these earlier studies are somewhat too high, due to deterioration during use of U.S.P. reference cod liver oil no. 1 which was used both as a reference standard in bioassays of the carotene supplements and as a supplement to the human vitamin A-deficient diet. The significance of these results is discussed.—*Wistar Institute.*

Kingsley, Helen N., Helen T. Parsons, "The Influence of the Ingestion of Fresh and Dried Bakers' Yeasts Varying in Viability and in Thiamine Content on the Availability of Thiamine to Human Subjects," *Journal of Nutrition,* 34:3, pp. 321-331 (September, 1947).

Thiamine in an unfortified fresh bakers' yeast ingested by human subjects was unavailable for absorption. A highly fortified control yeast released a large part of its thiamine in vitro but nevertheless yielded only a small proportion for absorption in vivo. The ingestion of a fresh unfortified bakers' yeast as a supplement to a weighed basal diet lowered the urinary output of thiamine; hence apparently interfered with the absorption of food thiamine, the effect being greater on the larger yeast dose of 150 gm per day. The length of time of ingestion of fresh yeast affected the speed with which the previous level of urinary output of thiamine was again attained when yeast was removed from the diet, indicating a progressive depletion of body stores from ingestion of fresh yeast. The drying of bakers' yeast did not of itself influence significantly the effect of the yeast on thiamine absorption; live dried yeast suitable for leavening also withheld its thiamine from absorption and interfered with the absorption of food thiamine judged by decreases in urinary output. On the other hand, bakers' yeast killed by certain commercial drying processes or by treatment in boiling water released its thiamine for absorption and offered no interference to the absorption of food thiamine. It is believed that live yeast cells in the digestive tract compete with the host for thiamine present.—*Wistar Institute.*

Price, Echo L., Mona M. Marquette, Helen T. Parsons, "The Availability of Vitamins from Yeasts," *Journal of Nutrition,* 34:No. 3, pp. 311-319 (September, 1947).

The degree of absorption of riboflavin of various yeasts from the digestive tract was judged by urinary excretions and, in some experiments, fecal outputs, in studies utilizing human bioassay methods. There was little or no absorption of riboflavin from the fresh, raw yeast and only partial absorption from 2 dried yeasts which contained live cells. The destruction of the viability of the yeast in 3 samples resulted in release of the riboflavin rendering it available for absorption. Fecal riboflavin eliminations were in a general reciprocal relationship to urinary excretions of the vitamin, indicating that when urinary excretions showed failure of absorption of the yeast riboflavin, fecal riboflavin was increased. Both unabsorbed riboflavin and intestinal synthesis appeared to contribute to increases in fecal riboflavin.—*Wistar Institute.*

Heftmann, Erich, "Some Studies on the Nutritive Value of Butter Fatty Acids," *Journal of Nutrition,* 34:4, pp. 455-467 (October, 1947).

The effect of the volatile and the unsaturated fatty acids of butter on the weight gain of young rats was investigated. During a 5-week period groups of 5 male and 5 female Wistar rats were fed a Sherman B diet the fat component of which was replaced by butter fatty acids. Weight gain and efficiency of food conversion were not significantly affected by replacement of the dietary fatty acids with a supplement of butter fatty acids stripped of the volatile fraction by steam-distillation. But a statistically significant reduction in the

weight gain of the males due to decreased efficiency of food conversion was observed when the iodine value of the fatty acids was reduced from 59.1 to 40.6 by hydrogenation. When the experiment was repeated with completely hydrogenated fatty acids, but a more liberal supplement of vitamins A and D, unsaturation was found to have no effect on weight gain or efficiency of food conversion of males or females. The amount and concentration of vitamin A stored in the livers of rats fed preformed vitamin A was not significantly affected by complete hydrogenation of the butter fatty acids in the diet.—*Wistar Institute.*

Scott, Edward M., "Self-Selection of Diet," *Journal of Nutrition,* 34:4, pp. 401-407 (October, 1947).

When young growing rats were offered their choice of casein, fat, salt mixture, and a carbohydrate, all animals disliked lactose, but starch, dextrin, or sucrose were accepted fairly well. The appetites for various carbohydrates were concluded to be largely independent of appetite for casein, inversely related to fat intake, independent (except possibly lactose) of nutritional significance, dependent on the method of offering the choices (i.e., whether in mixed diets or as pure substances) and independent of each other. Rats appeared to relish a change in the carbohydrate portion of their ration.—*Wistar Institute.*

Melnick, Daniel, Melvin Hochberg, Bernard L. Oser, "Physiological Availability of the Vitamins," *Journal of Nutrition,* 34:4, pp. 409-420 (October, 1947).

It has been postulated by others that fruits and vegetables contain an unknown factor, a covitamin, required for the effective utilization of ascorbic acid. Accelerated holding tests have demonstrated that the vitamin is far more stable in fruit juices (orange and enriched apple juice) than in aqueous ascorbic acid solutions adjusted to the same pH. Biological assays were conducted with human subjects to determine the availability of the ascorbic acid supplied by (a) enriched apple juice or (b) a normal adequate ration containing a variety of fruits and vegetables. Despite the concomitant ingestion of ascorbic acid stabilizing factors the latter products furnished the vitamin, the urinary excretion values were found to be no different than those obtained when the ascorbic acid was supplied in pure aqueous solution supplementing a dietary devoid of fruits and vegetables but simulating a normal adequate ration in proximate composition and vitamin content. It has been concluded that the findings by others of an enhanced biological potency for the ascorbic acid in fruits and vegetables is not due to the presence in such natural products of a factor which permits greater absorption and more effective utilization of the vitamin. On the basis of in vitro and in vivo studies, it was concluded that apple juice is a favorable vehicle for ascorbic acid in the human dietary.

Blumberg, Harold, Aaron Arnold, "The Comparative Biological Availabilities of Ferrous Sulfate Iron and Ferric Orthophosphate Iron in Enriched Bread, *Journal of Nutrition,* 34:4, pp. 373-387 (October, 1947).

Ferric orthophosphate has been widely used as a source of iron for bread enrichment, although very little information has been reported on its biological utilization. Therefore, a comparison was made of the biological availabilities of the iron in ferric orthophosphate and in the highly assimilable ferrous sulfate, as determined by hemoglobin regeneration in iron-deficient anemic rats. A secondary comparison with ferric chloride was also made. The iron compounds were fed in the form of enriched breads in the following diet: bread (dried) 81%, casein (low-iron) 12%, salt mixture (low-iron) 3%, corn oil 3%, plus copper, manganese, and the usual vitamins. Multiple levels of iron enrichment were used to permit comparison of dosage response curves. The

diets contained the added iron in the following concentrations: ferrous sulfate iron, 4.3, 8.6, 17.2, and 34.3 ug/gm; ferric orthophosphate iron, 6.9, 17.2, 43.1, and 108 ug/gm; and ferric chloride iron, 8.6 and 17.2 ug/gm. Under the conditions of these experiments, ferrous sulfate iron was approximately 4 times as available as ferric orthophosphate iron. Ferrous sulfate iron and ferric chloride iron were equal in biological availability. Attention is called to the desirability of using highly assimilable forms of iron in flour and bread enrichment.

Physical Anthropology

Lasker, Gabriel W., "The Effects of Partial Starvation on Somatotype. An Analysis of Material from the Minnesota Starvation Experiment," *American Journal of Physical Anthropology,* (ns), vol. 5, No. 3, pp. 323-341 (September, 1947).

Under the direction of Dr. Ancel Keys and his co-workers at the University of Minnesota, 34 volunteers were limited to a European type of famine diet for 24 weeks. During this period they lost an average of 24% of their body weight. Somatotyping techniques have been applied to standardized nude photographs taken at the beginning and end of this period to see whether so-called "constitutional" traits are influenced by changed dietary conditions.

Though partially starved individuals do not look identical to habitually linear individuals, applications of somatotype criteria proved practicable. Using Sheldon's technique of somatotyping, the majority of traits are shown to change in most of the individuals. Every individual shows a noticeable change in somatotype. Only in the wrists and ankles, hands and feet is there ordinarily little change. Similarly, preliminary studies by 5 somatotypers working under the direction of Dr. James Andrews in Professor Hooton's laboratory at Harvard confirm the finding of changed somatotype in every individual. Furthermore, 17 measurements taken by Sheldon as indicative of somatotype all show a tendency to decrease in the present series, most of them in every individual. The technique of somatotyping as applied in this study would thus seem to be strongly affected by nutritional status and of little use as a measure of inherited tendencies unless environmental factors are rigorously controlled.—*Wistar Institute.*

Jones, Harold E., "The Relationship of Strength to Physique," *American Journal Physical Anthropology* (ns), 5: 1, pp. 29-39 (March, 1947).

In a group of 80 public school boys, approximately 17.5 years of age, the relationship was studied between static dynamometric strength, height, weight, and assessments of somatotype. Strength was found to be positively related both to body size (especially weight) and to the mesomorphic compound of body build. Mesomorphy, however, had little or no relation to weight and was negatively correlated with height. Striking exceptions occurred to the relationship between strength and size, as illustrated by boys who were large but weak, or small but mesomorphic and strong. Taken alone, weight accounted for only 25% of the variance in strength, but 75% of the variance was controlled when the components of body build were included with weight and height, in proportions based on a multiple regression equation.—*Wistar Institute.*

Matheny, Walter D., Howard V. Meredith, "Mean Body Size on Minnesota Schoolboys of Finnish and Italian Ancestry," *American Journal of Physical Anthropology* (ns), 5: 3, pp. 243-356 (September, 1947).

A descriptive and comparative investigation is reported on the mean size of North American schoolboys of 2 ethnic groups. For each group, means are presented at successive annual ages from 6 to 17 years. Sixteen different physical traits are characterized, the data for 14 consisting of direct measure-

ments of the body and that for the other 2 of derived measurements. The subjects, approximately 1,100 boys of Finnish ancestry and 880 of Italian ancestry, were secured through schools in the vicinity of Hibbing, Minnesota. In addition to being obtained in the same geographic region, both series of subjects were studied at the same time (1938-39), were examined by the same anthropometrist (Matheny), and were similar for socio-economic status (fathers predominantly unskilled or semi-skilled workmen). Findings are drawn first from the original materials on schoolboys whose ancestors came from Finland and Italy, and then from reference to materials in the literature on North American white schoolboys whose ancestors came from other European countries (e.g., the Netherlands, Poland.)—*Wistar Institute.*

Physical Education

Vandell, R. A., R. A. Davis, and H. A. Clugston. "The Function of Mental Practice in the Acquisition of Motor Skills," *J. Gen. Psychol.* 29:243-250 (October, 1943).

A group of 12 senior high school boys practiced 35 basketball free-throws under one of 3 conditions:

1. On the 1st and 20th day.
2. On each of 20 days.
3. On the 1st and 20th day, with 15 minutes of "mental" practice daily from the 2nd through the 19th day.

Similar experiments were with dart-throwing, using 12 junior high school boys and 12 college freshmen. The subjects were equated in motor ability and other factors. The mental practice consisted of "imagining throwing the basketball or darts at the target" while sitting comfortably.

On the average, group 1 (no practice) showed no learning, group 2 (physical practice) showed 24 percent improvement; group 3 (mental practice) showed 23 percent improvement. Improvement in basketball free-throws was relatively large (41 percent for 2 and 43 percent for 3). The authors conclude that mental practice is about as effective as physical practice.—*F. Henry.*

Leavitt, H. J., and H. Schlossberg, "The Retention of Motor Skills," *J. Exp. Psychol.*, 34:404-417 (October, 1944).

"There is a widespread belief that motor habits are retained better than are verbal materials."

A purely motor task (pursuit rotor) and a verbal task (nonsense syllables) were equated in difficulty by adjusting the length of the list of syllables. Forty-eight subjects were given the same original learning—10 trials on both motor and verbal tasks.

There was considerable reminiscence in the motor task. Compared with the original learning score, there was 130 percent retention after an interval of 1 day, 118 percent after 1 week, 110 percent after 4 weeks, and 75 percent after 10 weeks. The verbal material showed no reminiscence; retention ranged from 82 percent after 1 day to only 10 percent after 10 weeks. Retention of the motor material was also considerably better than the verbal when measured by the savings method.

The reminiscence cannot be explained by postulating perseveration, since this would have been greatest with the verbal material. It is possible that the motor material was retained better because it presented a more integrated task. Retroactive inhibition may explain the results, since it would have been slight with the motor task and considerable with the nonsense syllables.—*F. Henry.*

Travis, R. C., "A New Stabilometer for Measuring Dynamic Equilibrium in the Standing Position," *J. Exp. Psychol.*, 34:418-424 (October, 1944).

The subject balances himself on a small platform that is supported in its

center by a universal joint. Springs on each corner tend to hold the platform level. Electric impulses at the rate of 5 per second feed into an impulse counter. The counter circuit includes contacts arranged to interrupt the current if the platform tilts more than 2 degrees. With perfect balancing of the platform, a perfect score would be 300 counts (per minute). No individual has yet produced a perfect score; the poorest of 321 subjects tested had a score of 30 counts.

Weight and height are found to decrease the stability of postural balance. There is a small sex difference, probably due to these factors. Test-retest reliability ranges from r = .80 to .86. Some improvement in scores occurs with practice. Preliminary studies indicate poor performance results from fatigue, loss of sleep, recent violent exercise, and alcohol. Individuals with training in dancing, skiing, gymnastics, and skating score above the average.—*F. Henry.*

Bush, Wayne L., "Rules Development (of Volley Ball,)" *Journal of Physical Education,* 43:2 (November-December, 1945).

This is a historical review of the development of the rules of volleyball from 1895 when the game was invented by William G. Morgan, a YMCA physical director at Holyoke, Mass., to the present time. The writer analyzes the playing equipment (net and ball), playing space, net height, size of court, playing conditions, fouls, blocking and scoring and the various rule changes.—*Harold T. Friermood.*

Smith, Chester C., "The Third National YMCA Health Service Clinic," *Journal of Physical Education,* 42:2 (November-December, 1945).

A study of the special training processes used by the YMCA to improve the competence and professional status of its health service operators. During this intensive clinic program specialists from the Medical College of Virginia, McGuire General Hospital, the County Medical Society, and YMCA officials united in presenting lectures, demonstrations, moving pictures, and supervised practice work. Visitations, special exhibits, library facilities, study halls, personal interviews, and written projects aided in a valuable workshop experience. A 58-page report, specially edited, presented the full clinic materials. —*Harold T. Friermood.*

Miller, Karl R., "Recapping the Tired Business Man," *Journal of Physical Education,* 43:2 (November-December, 1945).

A camping program for business men started 25 years ago continues to attract some of the original campers. Two hundred men can be accommodated for the 10-day period. The camp program emphasizes rest and change and consists of passive and active phases. The passive program consists of rest periods, quiet hours, and fishing. The active program includes recreational, social, and educational pursuits.

To insure democracy a camp council of five elected by the campers operates the camp program and advises with the camp director. Campers may choose to participate in all, some, or none of the scheduled activities. The individualists are encouraged. Strict adherence to all quiet hours within the tent area is maintained.

The day starts at 6:30 A.M. with calisthenics and a dip in the lake for those who desire it. Taps sound at 10:30 P.M.

Good food, hikes, swimming, boating, fishing, visitations, explorations, physical and social recreation, talks, lectures, movies, entertainments, evening vespers, special stunts, singing, and a daily news sheet are all on the program.

Two special features that develop unity and interest between the annual camp sessions are the October Sunday service attendance at the church of the

past season's "sky-pilot," and the April camp reunion in the city YMCA building.

This program has considerable merit in these days of high pressure, tension, and emotional strain. A study of geriatrics, later maturity, may reveal new uses for camping in line with this 25-year experiment.—*Harold T. Friermood.*

Griffin, Edward L., Logan Mundt, "Volleyball as used in the Army's Convalescent Training Program," *Journal of Physical Education,* 43:2 (November-December, 1945).

The convalescent training program bridged the gap between hospitalization and active duty and consisted of graded physical education mild pre- and post-operative exercises in hospital beds to the most strenuous. Volleyball ranked No. 1 both from the viewpoint of those administering as well as those participating in the program. At one convalescent center 2,000 men used 27 outdoor and two indoor volleyball courts six hours a day for training and free play. A larger number were in casts, on crutches, or had to use canes. Game adaptations had to be made. Patients were graded from class "E," most passive, to class "A," most active.

Some trainees with injured legs, using canes or crutches, could not stand long. Folding chairs were placed on the court in two or three rows and players sat, playing the game by throwing the ball over the net and catching it instead of serving and batting the ball over. With some groups play was carried on with both arms over head. Other groups used just the left or just the right arm for special development. "Shower" ball was a game that used several balls simultaneously in the same game for short periods to get rapid action. Rule books were studied and as players advanced to classes C, B, A the official rules governed play. At B and A levels organized teams, leagues, and highly competitive games were promoted. Mental and physical improvement were rapidly attained through this process.—*Harold T. Friermood.*

White, Robert J., "Testing Volleyball Playing Ability in Competitive Game Situations," *Journal of Physical Education,* 43:2 (November-December, 1945).

This article, based upon an Ohio State University thesis prepared for a master of arts degree, purports to grade volleyball playing ability during actual games. Fifteen original skills were reduced to six fundamental skills (pass—including setup, spike, block, serve, offensive tip shot, and retrieves). Each skill was defined. Then successful and unsuccessful performance of each skill was determined. A score sheet was developed allowing space for six names with space provided for checking each skill. There was a further division to indicate whether the skill was performed in the front or back court. Opportunity was provided the contestants to make each play at least 10 times (with successful or unsuccessful scores being recorded). Only two players were observed at a time during any one game. Eleven freshmen from O.S.U. and 22 Columbus YMCA advanced players were studied. A total of 330 observations were made of these players under game conditions. The final test score of each player was the total successful performances made during 10 observations.

The criterion with which the test was compared in order to determine its validity was the sum of four rank order scores. Scores were obtained from two observers each of whom ranked the players twice. The reliability of the YMCA group criterion was .992. The coefficient of reliability of the test for the YMCA class was found to be .708. The validity of the scores computed from the total successes was .629 for the YMCA group.

These observational tests check performance skill under game conditions rather than measuring isolated skills, but they require a great amount of time to administer and operate best when employed over an entire playing season. The tests may be used to classify players at the beginning of a season or to determine improvement during a season. Analysis of score results serves as a diagnostic procedure to determine elements of weakness with attention then directed to correcting these specific weaknesses or faults.—*Harold T. Friermood.*

Physiology

Karpovich, Peter V., "Breath Holding as a Test of Physical Endurance," *The American Journal of Physiology*, 149: 3, pp. 720-723 (June, 1947).

This study was an evaluation of various forms of breath holding as tests of physical fitness. The relationship sought was between breath holding and cardiorespiratory efficiency. As criterion measures of cardiorespiratory function a treadmill run to exhaustion and the Harvard step-up tests were used.

Five different tests of breath holding were employed: (1) in sitting position after three consecutive deep inhalations, (2) in sitting position after one full exhalation, (3) in sitting position after one inhalation immediately following one minute of prescribed exercise, (4) while stepping up and down on 10-inch bench, (5) while stepping up and down on 20-inch bench.

These tests were administered to 48 aviation students and the results correlated with the duration of treadmill running and score on Harvard step-up test. None of these correlations was found to be statistically significant. Hence it was concluded that breath ability cannot be used to predict either endurance running or Harvard step-up scores.—*Hector W. Kay.*

Weiss, Raymond A., Karpovich, Peter V., "Energy Cost of Exercise for Convalescents," *Archives of Physical Medicine*, 28, pp. 447-454 (July, 1947).

The study, of which this paper was the first published report, was conducted at the Physical Fitness Laboratory of the AAF School of Aviation Medicine, Randolph Field, Texas. In it was analyzed the energy cost of forty-two exercises, ranging in physiological gradation from side bending in the standing position to the "Burpee" exercise. The energy cost was expressed in multiples of resting metabolism, which meant that the authors determined the amount of oxygen used in the several exercises. What they have really offered the professions of medicine and physical education is a "cost list" for exercises, which can actually be prescribed physiologically, just as drugs can be regulated as to dosage. The principles followed are sound, and the application of the method has unlimited possibilities in therapeutic exercise and in physical education for conditioning. Incidentally, the exercises have been described by very clever drawings, which have eliminated the necessity of using any gymnastic nomenclature, and which have made this article particularly useful to physicians, as well as to physical therapists and teachers of physical education of varying backgrounds.—*Josephine L. Rathbone.*

Sussman, Maurice, Sol Speigelman, John Maximilian Reiner, "The Dissociation of Carbohydrate Assimilation from Catabolism." *J. Cell. and Comp. Physiol.*, 29: 2 (April, 1947).

The properties of the enzyme phosphorylase suggested that high pH might be employed as a method of dissociating polysaccharide synthesis from glucose metabolism in the intact cell. Experiments testing this supposition were performed. It was found that whereas more than 20% of fed glucose is assimilated at pH 4.5, only about 6% is assimilated at pH 8.5.

It is suggested that the experimental conditions described might provide

the opportunity for studying other synthetic activities (protein and fat) uncomplicated by the formation of polysaccharide.—*Wistar Institute.*

Keen, J. A., "On the Suitability of the Albino Rat in the Teaching of Human Embryology," *Anat. Rec.*, 99: 1, pp. 115-126 (September, 1947).

The author reviews the literature dealing with the following: (a) The oestrous cycle of the albino rat, and the time relation of the cycle to ovulation and insemination, (b) the determination of the stage of the oestrous cycle by vaginal smears, the detection of the copulation plug, the increase in weight of the pregnant rat, and the placental sign. In the author's opinon the vaginal smear method is uncertain. A simplified method of accurately timing rat embryos is described which does not involve the examination of vaginal smears. Details are given on the removal and fixing of rat embryos, a series of fixed and wax-impregnated embryos being illustrated. Transverse sections of rat embryos are figured, and are compared with corresponding sections of human and pig embryos. The author concludes that the albino rat is a representative mammalian type which is very suitable for use in the teaching of human embryology.—*Wistar Institute.*

Tyler, David B., "The Effect of Amphetamine Sulfate and Some Barbiturates on the Fatigue Produced by Prolonged Wakefulness," *American Journal of Physiology*, 150: 2, pp. 253-262 (September, 1947).

The effects of benzedrine sulfate and two barbiturates: amytal and ethylmethyl thio-barbituric acid (V-12) were studied on 275 volunteer subjects in the armed services. Objective criteria for the effects of experimental insomnia were a wide variety of psychomoter tests. Contrary to popular belief, it was found that 112 hours of wakefulness only slightly decreased muscular strength. A marked decrease in endurance, however, was noted which Tyler attributes to the increased difficulty of retaining wakefulness and not to muscular weakness. From his observations, fatigue seems to be located in the higher centers of the central nervous system. The quantity of barbiturates (4 gr. of amytal or 10 gr. of V-12) administered during the 112-hour experiment showed little effect on psychomoter tests or ability to keep awake. The effects of benzedrine were negligible during experiments of short duration, i.e., 32 to 48 hours. During experiments that lasted 72 to 112 hours, benzedrine increased wakefulness and resulted in some better psychomoter test scores. It was administered every 8 to 12 hours in 5 to 10 mgm. doses. Following 112 hours of experimental insomnia, 8 to 14 hours were generally sufficient for complete recuperation.—*Richard I. Miller.*

Psychology

Brower, D., "Respiration and Blood Pressure in Sensory Conflict," *J. Gen. Psychol.*, 34, pp. 47-58 (Jan., 1946).

Blood pressure and breathing records were secured on 18 college men while they participated in a mirror-tracing experiment using the dominant hand. In a second-conflict situation, the subjects were blindfolded. Control measurements were made before and after the "conflict" tests. The results indicate that the circulatory measures are in the emotive category; breathing is predominantly orientive, although "amplitude" and "inspiration fraction" represent somewhat diverse factors since their intercorrelation is approximately zero in the conflict situations although it is significant ($r \pm -.55$) for the control. The inspiration-fraction seems to be an indicator of frustrationality and emotionality. Some subjects exhibit *less* emotional activity directly after conflict than during the pre-conflict period.—*F. Henry.*

Duffy, Elizabeth, "Level of Muscular Tension as an Aspect of Personality," *J. Gen. Psychol.*, 35, pp. 161-171 (October, 1946).

The grip pressures of the used and unused hand, also pressure determined by the carbon-paper method, were measured while 25 college women performed 8 tasks including color-naming, tapping, letter and number cancellation, adding, and maze-tracing. The results were subjected to a Thurstone multiple factor analysis.

Factor I was identified as "general tension," regarded as a significant aspect of personality.

Factor II appeared to be the point-pressure carbon-paper technique during maze-tracing. Factor III seemed to be specific to color-naming, grip pressure of the unused hand, and "first experimental session."

Factor IV seemed to have some degree of generality as to variety of tasks, but tended to be specific to the carbon-paper technique.

The general factor of muscular tension is believed to be only one of a number of indicators of the energy mobilization of the individual. Others are electrical skin resistance and metabolism. Such measures represent the *intensity* of response to environmental situations.—*F. Henry.*

Eysenck, H. J., and H. T. Himmelweit, "An Experimental Study of the Reactions of Neurotics to Experiences of Success and Failure," *J. Gen. Psychol.*, 35, pp. 59-75 (July, 1946).

To test the hypothesis that introverts are more affected by subjective factors and extroverts are more affected by objective factors, 50 patients showing "anxiety and depression" (extreme introverts) and 50 of the "hysterical" type (extreme extroverts) were tested on a new type of integrating pursuit rotor. The groups were equated in age and intelligence; they were all neurotic male army patients with an average age of 30 years. The procedure was to ask each patient how many score points out of the possible 220 he thought he would be able to make (aspiration). After testing, he was asked how many points he thought he made (judgment); then he was told his actual score (performance) and the test was repeated 10 times.

There were no significant differences between the groups in performance or improvement. The introverted group showed greater differences between aspiration level and performance than did the extroverts; this was also true for the differences between judgment and performance. Thus the reactions of the extroverts were more objective, since they were closer to external reality (performance) than the introverts.—*F. Henry.*

Jones, M. R., "Studies in 'Nervous' Movements: III. The Effect of Mechanical Inhibition of Movements in One Category of the Frequency and Patterning of Movements in Other Categories," *J. Gen. Psychol.*, 35, pp. 17-26 (July, 1946).

If "nervous" bodily movements are conditioned responses, the inhibition of one category of movements should decrease the movements in other categories (law of generalization of inhibition). This concept was examined experimentally by observing through a one-way screen the bodily movements of 24 high school boys who participated in what they were told was an experiment designed to study muscular control. Steadiness tests were given at intervals to support the explanation. Four 20-minute rest periods intervened between the pseudo-tests; the subject was unrestrained in the first and last of these, but in the other 2 he wore a fixed head-stall that mechanically eliminated nearly all head movements. During one of the periods of restraint he did mental arithmetic problems.

Movements were classified into 13 categories; the odd-even (corrected) reliabilities ranged from .71 to .98. The mean frequency of movements in all categories was reduced by the inhibition of one category. There was a sug-

gestion of an anatomical gradient of inhibition. The effects of mental arithmetic were essentially the same during restraint as during a previously reported observation under "free" conditions. The conditioned response hypothesis appears justified.—*F. Henry* .

Krawiec, T. S., "A Comparison of Learning and Retention of Materials Presented Visually and Auditorially," *J. Gen. Psychol.*, 34, pp. 179-195 (April, 1946).

The retention of nonsense syllables and nouns, measured by recall, relearning, and saving scores, was determined for one week with 30 individuals and for 2 weeks with 37. The subjects were college men and women. Both visual and auditory presentations were used.

The visual method was superior for original learning. In retention, there were only small and unreliable differences between the effectiveness of the two methods.—*F. Henry.*

Springer, N. N., "The Validity of the Multiple Choice Group Rorschach Test in the Screening of Naval Personnel," *J. Gen. Psychol.*, 35, pp. 27-32 (July, 1946).

The group Rorschach (inkblot) personality test is not effective; it failed to distinguish between individuals classified objectively or psychologically as normal, chronic disciplinary offenders, psychoneurotics, psychopaths, and persons with behavior disorders.—*F. Henry.*

Welch, L., "The Inclusion of Both Physiological and Acquired Needs in a Behavioristic System," *J. Gen. Psychol.*, 35, pp. 87-97 (July, 1946).

The organism, by virtue of environmental factors, becomes attracted to some stimuli and repelled by others. Adaptation and learning are both involved. "Men have starved to death on a life raft rather than eat raw fish, which they have never *learned* to like." The organism is repelled by sudden environmental change; it is also repelled by the monotonous situation of no change. Adaptation involves the dissipation of the extent of environmental change in terms of the frequency of presentation of the new environmental factor, which may eventually come to attract the organism.—*F. Henry.*

Yates, Dorothy H., "Relaxation in Psychotherapy," *J. Gen. Psychol.*, 34:213-238 (April, 1946).

A personalized clinical account of the author's experience with her method of relaxation therapy is given. While Jacobsen is commended for pioneering, his method (progressive relaxation) is suited to experimental purposes rather than practical use. The treatment is too long and detailed; there is no practical necessity for complete relaxation. The most serious objection is his disregard of the individual's "thought life" and attitudes.

The Yates association-set method involves "explanation, confidence-building, motivation, and self-direction, specific objectives, intensity, and helpful substitution in learning, as well as pleasantness, conditioning, set, and the utilization of sleep as rest periods for retention." The method is eclectic, using everything possible. "It would obviously be wise to test it out experimentally with control groups. However, important as this is, it must be remembered that there is not quite the ordinary necessity for experimental check, since the technique is based on a composite of well established psychological principles. . . The present form should be modified for use by others on large groups, perhaps service men or athletes."—*F. Henry.*

Sociology

Jackson, Reid E., "Background Factors for Negroes Listed as Leaders in Education," *School and Society*, 66:1705, pp. 164-169 (August 30, 1947).

The 1941 edition of *Leaders in Education* published by the Science Press

was reviewed. Of the 17,500 persons listed, 146 or .86% were negroes. This is lower than might be expected considering 19 percent of the total U. S. population is negro.

The ages of the negroes listed ranged from 26 to 80, the median age being 47.6 years. Approximately one-third of the negro educational leaders earned a doctor of philosophy degree. Only one woman of the 12 listed had gained this degree.

The leaders tended to remain in the regions in which they were born. Nearly three-fourths of the negro leaders are engaged in reputable educational institutions: 46.5% are administrators and 29.5% are teachers.—*Carolyn Bookwalter.*

Book Review

Speed in Animals: Their Specialization for Running and Leaping. A. Brazier Howell. Chicago: University of Chicago Press, 1944, 270 pages.

This book presents the conclusions of the author regarding the effects of specialization in running and leaping activities upon the bone and the muscle anatomy of animals. He states that, "the factor of speed either defensive or offensive has been one of the most powerful factors if not the most powerful, in evolution." He concludes that no animal is perfectly fitted for its particular existence but that each animal is a compromise, evolution having taken the available material and having done the best possible with it. He concludes, also, that man is not a cursorial mammal; that is, that man, when compared with other animals, is not a fast runner because he has depended primarily upon his superior intelligence for survival.

From the point of view of readily applicable factual material relating to man, this book has little to offer to the average physical educator, for it deals almost entirely with animals. Chapter V, which deals with the modifications of the muscular system in animals, is partially applicable to man and should be of interest to students of kinesiology. Chapter VI contains information on the structure of the axial skeleton in various animals and discusses the influence of postural stresses in determining structure. Chapter IX is an interesting analysis of the factor of bodily proportions and its influence on cursorial ability. This chapter contains ideas which might suggest topics for research in physical education. The final chapter is a complete summary of the major conclusions of the author and is the most valuable section of the book for the average reader.

This treatise is highly technical. It requires a thorough knowledge of anatomy for adequate comprehension and its usefulness is therefore limited to specialists and research workers in anatomy, kinesiology, and allied fields.

ARTHUR J. WENDLER
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Since three members of the Board of Associate Editors review an article it is requested that at least two copies of the manuscript (the original and a clear carbon) be submitted in order to facilitate reviewing. The carbon copy will be returned to the author with galley proofs for checking. Manuscripts should be double spaced.

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Ogden, Jean and Jess. Small Communities in Action. New York City: Harper & Brothers, 1946. (books)

Deaver, G. G. Exercise and heart disease. *Research Quarterly*, 10:24-34, 1939 (periodicals)

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